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ABSTRACT

These teacher and student editions on steering and suspension are part of the diesel mechanics series of instructional materials. The series aligns with the medium/heavy duty truck task list developed by the National Automotive Technicians Education Foundation and used by the National Institute for Automotive Service Excellence in the certification of medium/heavy duty truck technicians. The teacher edition consists of introductory pages (use of this publication, training and competency profile, national skills crosswalk, instructional/task analysis, basic skills icons and classifications, basic skills matrix, and tools, equipment, and materials list), teacher pages for each unit (unit contents, suggested activities, answers to assignment sheets, written test, answers to test, learning activities sheet, teacher supplements, transparency masters), and the student edition which contains these components for each unit: unit contents, objective sheet, information sheet, student supplements, assignment sheets, and job sheets. Section A: Chassis, Tires, and Wheels has these three units: cab components; tires, rims, and wheels; chassis components. Section B: Steering has these three units: steering column and manual steering gear, power steering systems, steering axle components. Section C: Suspension has five units: front suspension, rear spring suspension, rear beam suspension, rear air suspension, vehicle alignment. (YLB)

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ED 475 400

Diesel Technology

Steering and Suspension

Second Edition

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Teacher Edition

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Diesel Technology: Steering and Suspension

Teacher Edition

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Carl Tesch
Mary Kellum

Project coordinated by

Mary Kellum

Developed by

The Multistate Academic and Vocational Curriculum Consortium, Inc.

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Units of Instruction

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Section B: Steering

Unit 1–B: Steering Column and Manual Steering Gear

Unit 2–B: Power Steering Systems

Unit 3–B: Steering Axle Components

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Unit 2–C: Rear Spring Suspension

Unit 3–C: Rear Beam Suspension

Unit 4–C: Rear Air Suspension

Unit 5–C: Vehicle Alignment

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Corrections

Publication Title ______________________________

Page Number	Correction

Suggestions

- Product Needs (supplemental resources, additional publications, etc.)

____
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- Other Ideas

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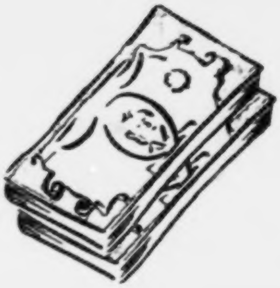

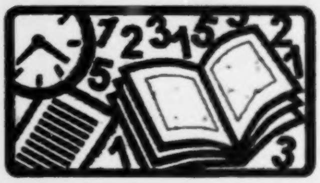

- **Ensure sequential learning** by using MAVCC's unique format that moves the student from simple to complex objectives.
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Key Components of Student Editions

Student Guides

◊ Learning Activities Sheet
◊ Objective Sheet
◊ Information Sheet
◊ Student Supplements

Student Workbooks

◊ Focus Assignments
◊ Assignment Sheets
◊ Job Sheets

For more information about these components, please refer to the "Use of This Publication" section found in the front of your teacher edition

Contact MAVCC now to purchase your student editions:

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Foreword

When MAVCC began the process for revising its diesel mechanics series, we wanted to develop a set of instructional materials that would provide students with the cognitive (knowing), psychomotor (doing), and affective (attitude) skills necessary to be successful in the diesel trade and that would address the emerging technology in the field. With the help of extremely qualified teachers, industry representatives, and writers, our new diesel technology series offers secondary and postsecondary students an excellent opportunity for learning required skills in the diesel industry.

The series aligns with the medium/heavy duty truck task list developed by the National Automotive Technicians Education Foundation (NATEF) and used by the National Institute for Automotive Service Excellence (ASE) in the certification of medium/heavy duty truck technicians. Our series addresses all but one of the ASE certification areas, gasoline engines, and includes the following publications: Introduction, Safety Skills, Workplace Skills, Brakes, Steering and Suspension, Engines, Electrical and Electronic Systems, Drive Trains, and Hydraulics. Each publication will include a matrix showing where the NATEF tasks are being taught.

The new publications will also reflect those tasks identified by MAVCC's technical committee which were not covered in the NATEF task list, especially those dealing with the maintenance and repair of diesel-powered heavy equipment and agriculture equipment.

These instructional materials are designed for student use and to assist teachers in organizing and improving instruction. There design is based on the curriculum alignment concept of first stating the objectives (objective sheet), developing instructional strategies for teaching to those objectives (information, assignment, and job sheets), and assessing to those same objectives (criterion referenced evaluation instruments).

As with all MAVCC publications, teachers are encouraged to localize and personalize these materials to meet the needs of individual students, the community, and prospective employers. Teachers are also encouraged to develop strategies for motivating their students.

As you use these instructional materials, we hope that you will find they contribute to the quality of your program. If any problems occur or if you have any suggestions for improvement of the materials, please call, write, or e-mail us.

Kimberly Sadler, Chair
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Multistate Academic and
Vocational Curriculum
Consortium

Jane Huston
Executive Director
Multistate Academic and
Vocational Curriculum
Consortium

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The content of this publication was planned by the following members of the MAVCC diesel revision committee:

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Special appreciation is extended to Rick Lomenick, electronic publishing technician, for his excellent work on this project.

Appreciation is also extended to the Graphics Division of the Oklahoma Department of Career and Technology Education for the artwork and printing of this text.

Use of This Publication

Diesel Technology: Steering and Suspension is available in both a teacher and student edition. The contents of these materials are tied to measurable and observable learning outcomes that were identified and validated by the diesel revision advisory committee, comprised of business/industry representatives and teachers. Competencies align with the (title of task list/standards) developed by the (name of organization).

Teacher Edition

The complete teacher edition consists of introductory pages, teacher pages, and the student edition. Materials are loose-leaf (this varies) and three-hole punched and are divided into units of instruction that may be broken into more than one lesson or class period. For added flexibility, each unit is individually numbered beginning with a T for teacher page, followed by the unit number and page number.

Example:

Page 17 of Unit 3 in the teacher pages is represented as T 3–17.

MAVCC—*Diesel Technology: Steering and Suspension* T 3–17

Page 1 of Unit 5 in the teacher pages is represented as T 5–1.

MAVCC—*Diesel Technology: Steering and Suspension* T 5–1

Pages in the student edition are numbered beginning with the unit number, followed by the page number.

Example:

Page 7 of Unit 5 in the student edition is represented as Page 5–7.

MAVCC—*Diesel Technology: Steering and Suspension* Page 5–7

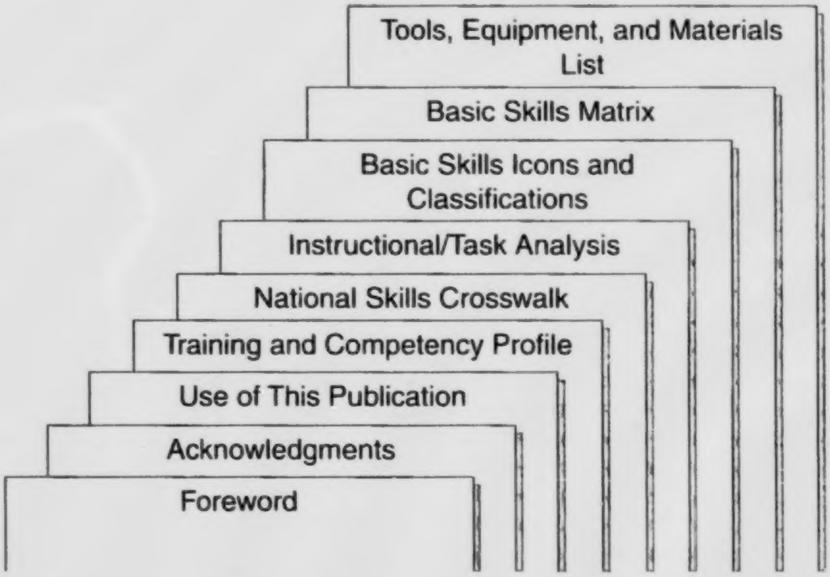
Use of This Publication

For group instruction, the teacher should determine the best way to teach each objective and allow for student participation. For self-paced or individualized instruction, students should be provided with opportunities to become involved in planning and being responsible for their own education. Careful study of each unit of instruction by the teacher will help to determine the following:

- amount of material that can be covered in each class period;
- supplies and materials required for assignment sheets and job sheets;
- resource people who must be contacted;
- supplementary materials to be ordered;
- skills that must be demonstrated and the amount of class time needed for demonstrations; and
- amount of class time needed for student practice and return demonstrations of mastered skills.

Teachers are encouraged to localize and personalize these materials to meet the needs of individual students, the community, and prospective employers.

Introductory Pages


Tools, Equipment, and Materials List
Basic Skills Matrix
Basic Skills Icons and Classifications
Instructional/Task Analysis
National Skills Crosswalk
Training and Competency Profile
Use of This Publication
Acknowledgments
Foreword

Use of This Publication

In addition to general information, such as the table of contents, acknowledgments, and the use of this publication, the following tools have been provided to assist administrators and teachers in planning for instruction.

- ☐ **Training and Competency Profile**. This form may be copied and used to record information about each student, such as enrollment dates, class attendance, and work experience, and to document the student's mastery of specific job competencies. It can also be used to provide information about the student's qualifications to potential employers and/or for entry into advanced training programs.

- ☐ **National Skills and/or State Duty/Task Crosswalk.** This document identifies the national and/or state skill standards covered in this publication and lists specifically where these skills are located by unit number and objective.

- ☐ **Instructional/Task Analysis.** This document provides a quick review of the contents of this publication by identifying the cognitive skills (what the student should know) and psychomotor skills (what the student should be able to do) addressed in each unit of instruction.

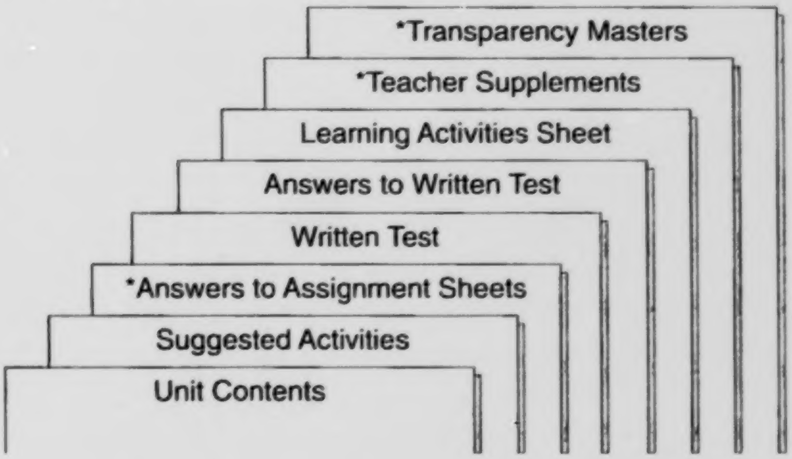
- ☐ **Basic Skills Icons and Classifications.** This page provides a reference guide of the graphic symbols that are used to identify the basic academic and workplace skills included in each focus assignment, assignment sheet, and job sheet.

- ☐ **Basic Skills Matrix.** This document graphically summarizes the academic and workplace skills training included in the instructional materials, unit by unit. It should be helpful to teachers in planning for instruction, and to administrators as documentation that basic skills are being taught as part of the vocational training.

- ☐ **Tools, Equipment, and Materials List.** This document provides a comprehensive list of those items needed in a vocational program for students to complete training. It also can assist administrators and teachers in determining program costs.

Use of This Publication

Teacher Pages



*Transparency Masters
*Teacher Supplements
Learning Activities Sheet
Answers to Written Test
Written Test
*Answers to Assignment Sheets
Suggested Activities
Unit Contents

*Designates components that may not appear in every unit of instruction

Teachers should study the teacher and student pages before introducing the unit, allowing enough time to obtain supplemental materials and to contact outside resource persons.

☐ **Suggested Activities.** This component assists teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, a list of references used in the development of each unit, and a list of suggested supplemental resources (books, posters, pamphlets, videotapes, computer software, and Internet sites) that may be used to enhance instruction.

Instructions for evaluating student performance on the assignment sheets and job sheets are also included in the suggested activities section. Teachers should select and discuss with students the rating scale that will be used.

☐ **Answers to Assignment Sheets.** An answer key is provided, when applicable, to assist the teacher in evaluating student performance on a given assignment.

☐ **Written Test.** This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction, and serves as both a pretest and posttest to assist teachers in measuring each student's competency gains. (Assignment sheet and job sheet objectives are not evaluated on the written test.) If the teacher has added, deleted, or modified any objectives, appropriate changes should be made to both the test and answers to the written test.

Tests may be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for a final test at the end of each term if desired. The written test is included in the teacher edition only and should be duplicated for student use.

☐ **Answers to Written Test.** An answer key is provided to assist the teacher in evaluating student performance on the written test.

☐ **Learning Activities Sheet.** This component provides a model for teachers to use in implementing a self-paced or individualized program, and guides the student through the required components in the student edition (objective sheet, information sheet, student supplements, assignment sheets, and job sheets). The teacher should modify the learning steps as needed to incorporate resources available in the classroom (videotapes, computer software, magazines, etc.) and to address instructional strategies that may be needed to enhance learning for each student. Final copies should be distributed for student use.

The following icons will be used on the learning activities sheet to denote steps that require additional resources:

📖 Read a book, magazine, or journal article

💻 Use a CBT program or other software application

WWW Access a site on the World Wide Web

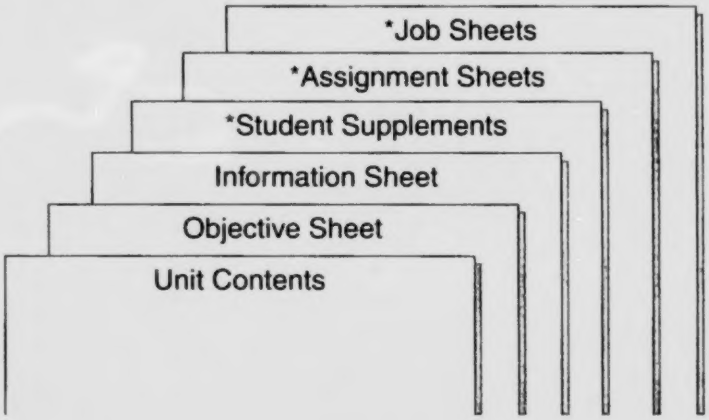
🖥 Look at PowerPoint® or other computer presentation

📼 Watch a videotape

☐ **Teacher Supplements.** These are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher-level materials to stretch the advanced student; with remedial information or practice to assist the less-advanced student; and with state-of-the-art information in which the teacher may not have a background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

☐ **Transparency Masters.** These overheads are used to direct the students' attention to the topic of classroom discussion. Transparencies allow the student to see as well as hear the information being presented, thus reinforcing the learning process. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction. Some of these items may also appear with the appropriate objectives in the information sheet in the student edition. The teacher may make acetate copies from the masters or, in most cases, complete transparency sets are available for purchase.

Student Edition



*Designates components that may not appear in every unit of instruction

For best results, students should be provided with a copy of the student edition and should be allowed to take notes in the margins as additional information is provided by the instructor or as the student acquires additional information through library or Internet research.

☐ **Objective Sheet.** This component summarizes each unit for the student and teacher. The objective sheet is based on established performance objectives that state the goals for successful completion of a unit of instruction. Objectives are stated in two forms: unit objectives that state the expected performance of each student after completion of the unit and specific (enabling) objectives that state what the student must be able to do to reach the unit objective.

The objectives should be stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods.

Teachers should modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion-referenced test items to cover the new objectives.

☐ **Information Sheet.** This component provides the student with the essential information for meeting the cognitive objectives in the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in the margins for students and teachers to add notes that clarify and/or expand upon the information presented.

☐ **Student Supplements.** This component is included in a unit of instruction when additional information is needed in order for students to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment and/or job sheets.

☐ **Assignment Sheets.** The assignment sheets address the learning levels at or above the application level of Bloom's taxonomy. They provide students with an opportunity to use higher-order thinking skills, such as problem solving, synthesizing, analyzing, and evaluating. In addition, they may provide additional opportunities for students to develop their language skills.

Assignment sheets can be paper-and-pencil activities, as well as those using computer software, videotapes, models, handouts, or other resources as appropriate. Criteria are provided to evaluate student performance objectively.

☐ **Job Sheets.** Job sheets are designed as skill tests and give the instructor direction as to the psychomotor skills to be taught, and provide the criteria to evaluate student performance objectively. They also help provide potential employers with a picture of the skills being taught during training and the performances that might be reasonably expected from an individual who has completed the training.

The teacher should provide students with a copy of each job sheet and/or the procedure's manual and/or job specifications when necessary. The teacher should also discuss the equipment and materials that will be needed for the job and the criteria that will be used to evaluate the student's performance, and demonstrate the procedure prior to having students practice the procedure. Safety should be stressed as part of each demonstration.

When a student is ready to be evaluated, the teacher should follow the instructions for evaluating student performance which may be found in the suggested activities component of the teacher unit.

As you use these instructional materials we hope that you will find that they contribute to the quality of your program. If any problems occur or if you have any suggestions for improvement of the materials, please write us at 1500 West Seventh Avenue, Stillwater, OK 74074-4364, or E-mail us at mavcc@mavcc.com.

Training and Competency Profile

Student Information

Program ______________________ Instructor ______________________

Name ______________________ Student ID No. ______________________

Address ______________________ Phone ______________________

Grade ______________ School ______________________

Allergies/Disabilities that might require special accommodation for training (please specify)

____

In case of emergency, contact ______________________ Phone ______________________

Record of Enrollment

Date of Enrollment ____- ____- ____ Total Class Hours________ Total Hours Absent________

Date of Withdrawal ____- ____- ____ Total On-the-Job Training Hours________ Total Hours Tardy________

Date of Completion ____- ____- ____ Total Lab Hours__________

On-the-Job Training/Work Experience

______________________ ______________________
Place of Employment Address

______________________ ______________________
Supervisor's Name Phone

______________________ ______________________
Duration of Employment Job Title

____
Job Responsibilities

______________________ ______________________
Place of Employment Address

______________________ ______________________
Supervisor's Name Phone

______________________ ______________________
Duration of Employment Job Title

____
Job Responsibilities

Training and Competency Profile

Student Evaluation

Directions: Evaluate the student using the rating scale below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focuses on a level of student performance for each of the tasks listed. The written test scoreline is provided for optional teacher use. It may not be applicable in all cases.

Rating Scale: Option A

4	Skilled—Can perform job with no additional training
3	Moderately Skilled—Has performed job during training program; limited additional training may be required.
2	Limited Skill—Has performed job during training program; additional training is required to develop skill.
1	Unskilled—Is familiar with process, but is unable to perform job.
0	No Exposure—No information or practice provided during training program, complete training required.
NA	Non-applicable.

Rating Scale: Option B

Yes—Can perform with no additional training
No—Is unable to perform satisfactorily

SECTION A: CHASSIS, TIRES, AND WHEELS

Unit 1–A: Cab Components

______ 1. Inspect, test, and adjust cab air suspension components and determine needed repairs.
______ 2. Inspect, test, and adjust driver's air seat components and determine needed repairs.
______ 3. ______________________
______ Written Test Score

Unit 2–A: Tires, Rims, and Wheels

______ 1. Diagnose unusual tire wear patterns, check tire pressure, and measure and match tires.
______ 2. Diagnose tire/wheel vibration, inspect mounting hardware, and check tire/wheel runout and balance.
______ 3. ______________________
______ Written Test Score

Unit 3–A: Chassis Components

______ 1. Inspect and install or repair frame, hangers, brackets,and cross members.
______ 2. Check and inspect vehicle frame alignment.
______ 3. Inspect and service fifth wheel assemblies, pintle hitch, kingpin, and trailer plate.
______ 4. Couple and uncouple fifth wheel.
______ 5. ______________________
______ Written Test Score

SECTION B: STEERING

Unit 1–B: Steering Column and Manual Steering Gear

______ 1. Diagnose and troubleshoot problems on the steering column and steering gear assembly.
______ 2. Remove steering wheel, inspect, repair, or replace to proper alignment position.
______ 3. Remove, disassemble, and remount the steering gear assembly.
______ 4. Perform steering gear adjustments.
______ 5. Inspect and replace pitman arm on steering gear assembly.
______ 6. Inspect and replace steering U-joints.
______ 7. ______________________
______ Written Test Score

Unit 2–B: Power Steering Systems

______ 1. Diagnose, test, and troubleshoot problems on a power steering system.
______ 2. Remove and repair/replace power steering gear.
______ 3. Rebuild power steering gear.
______ 4. Remove and replace power steering pump; adjust belt if used.
______ 5. Inspect, clean, disassemble, and rebuild power steering pump; replace worn parts.
______ 6. Test and repair/replace flow control/pressure relief valve(s) on power steering pump.
______ 7. Fill and bleed the power steering system.
______ 8. ______________________
______ Written Test Score

Unit 3–B: Steering Axle Components

______ 1. Select wheel bearings and seals.
______ 2. Remove, inspect, clean, replace, and adjust wheel bearings and seals.
______ 3. Repair or replace a steering knuckle assembly.
______ 4. Inspect and replace tie rod ends.
______ 5. Diagnose and troubleshoot the steering axle assembly.
______ 6. ______________________
______ Written Test Score

SECTION C: SUSPENSION

Unit 1–C: Front Suspension

______ 1. Inspect front suspension components.
______ 2. Remove and replace front spring suspension components.
______ 3. ______________________________
______ Written Test Score

Unit 2–C: Rear Spring Suspension

______ 1. Inspect rear spring suspension components.
______ 2. Replace rear spring suspension components.
______ 3. ______________________________
______ Written Test Score

Unit 3–C: Rear Beam Suspension

______ 1. Inspect rear beam suspension components.
______ 2. ______________________________
______ Written Test Score

Unit 4–C: Rear Air Suspension

______ 1. Inspect, test, and replace an air spring.
______ 2. Inspect and test an air suspension system, replace the leveling valve, and adjust frame (ride) height.
______ 3. ______________________________
______ Written Test Score

Unit 5–C: Vehicle Alignment

______ 1. Perform pre-alignment checks.
______ 2. Check camber and kingpin inclination; determine needed repairs.
______ 3. Check caster; adjust or repair as needed.
______ 4. Check toe; adjust as needed.
______ 5. Check rear axle alignment; adjust or repair as needed.
______ 6. Measure and adjust pinion angle.
______ 7. ______________________________
______ Written Test Score

Diesel Technology:
Steering and Suspension

National Skills Crosswalk

The following NATEF Suspension and Steering tasks (rev. 2001) are covered in this publication. The chart shows where each task is located within the publication. The first column identifies the NATEF task by name and number. The second column identifies the exact location by number and assignment sheet or job sheet number.

NATEF Tasks	MAVCC Tasks
V. Suspension and Steering	
A. Steering Systems Diagnosis and Repair	
1. Steering Column	
1. Diagnose fixed and driver adjustable steering column and shaft noise, looseness, and binding problems; determine needed action.	Unit 1-B, Job Sheet 1 – Diagnose and troubleshoot problems on the steering column and steering gear assembly.
2. Inspect steering shaft U-joint(s), slip joints, bearings, bushings, and seals; determine needed repairs.	Unit 1-B, Job Sheet 6 – Inspect and replace steering U-joints.
3. Check and adjust cab mounting and ride height.	Unit 1-A, Job Sheet 1 – Inspect, test, and adjust cab air suspension components and determine needed repairs. Unit 4-C, Job Sheet 2 – Inspect and test an air suspension system, replace the leveling valve, and adjust frame (ride) height.
4. Center the steering wheel.	Unit 1-B, Job Sheet 2 – Remove steering wheel, inspect, repair, or replace to proper alignment position.
5. Disable and enable supplemental restraint system (SRS) in accordance with manufacturer's procedures.	Not covered. (see MAVCC's Diesel Electrical and Electronic Systems publication)
2. Steering Units	
1. Diagnose power steering system noise, steering binding, darting/oversteer, reduced wheel cut, steering wheel kick, pulling, non-recovery, turning effort, looseness, hard steering, overheating, fluid leaking, and fluid aeration problems; determine needed action.	Unit 2-B, Job Sheet 1 – Diagnose, test, and troubleshoot problems on a power steering system.
2. Determine recommended type of power steering fluid; check level and condition; determine needed action.	Not covered. (see MAVCC's Diesel Preventive Maintenance publication)
3. Flush and refill power steering system; purge air from the system.	Unit 2-B, Job Sheet 7 – Fill and bleed the power steering system.

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NATEF Tasks	MAVCC Tasks
4. Perform power steering system pressure, temperature, and flow tests; determine needed action.	Unit 2-B, Job Sheet 6 – Test and repair/replace flow control/pressure relief valve(s) on power steering pump. Unit 2-B, Job Sheet 7 – Fill and bleed the power steering system.
5. Inspect, service, or replace power steering reservoir including filter, seals, and gasket.	Unit 2-B, Job Sheet 7 – Fill and bleed the power steering system.
6. Inspect, adjust, align, or replace power steering pump belt(s) and pulley(s)	Unit 2-B, Job Sheet 4 – Remove and replace power steering pump; adjust belt if used.
7. Inspect, replace as required, power steering pump drive gear and coupling.	Unit 2-B, Job Sheet 2 – Remove and repair/replace power steering gear.
8. Inspect, adjust, or replace power steering pump, mountings, and brackets.	Unit 2-B, Job Sheet 4 – Remove and replace power steering pump; adjust belt if used. Unit 2-B, Job Sheet 5 – Inspect, clean, disassemble, and rebuild power steering pump; replace worn parts.
9. Inspect and replace power steering system cooler, lines, hoses, clamps/mountings, hose routings, and fittings.	Unit 2-B, Job Sheet 2 – Remove and repair/replace power steering gear.
10. Inspect, adjust, or replace linkage-assist type power steering cylinder or gear (dual system).	Unit 2-B, Job Sheet 6 – Test and repair/replace flow control/pressure relief valve(s) on power steering pump.
11. Inspect, adjust, repair, or replace integral type power steering gear.	Unit 2-B, Job Sheet 2 – Remove and repair/replace power steering gear.
12. Adjust manual and automatic steering gear poppet/relief valves.	Unit 2-B, Job Sheet 2 – Remove and repair/replace power steering gear. Unit 2-B, Job Sheet 3 – Rebuild power steering gear.
3. Steering Linkage	
1. Inspect and align pitman arm; replace as needed.	Unit 1-B, Job Sheet 5 – Inspect and replace pitman arm on steering gear assembly.
2. Inspect drag link (relay rod) and tie rod ends (ball and adjustable socket type); adjust or replace as needed.	Unit 3-B, Job Sheet 2 – Repair or replace steering knuckle assembly. Unit 3-B, Job Sheet 3 – Inspect and replace tie rod ends.

NATEF Tasks	MAVCC Tasks
3. Inspect steering arm and levers, and linkage pivot joints; replace as needed.	Unit 3-B, Job Sheet 2 – Repair or replace steering knuckle assembly.
4. Inspect clamps and retainers on cross type/ relay rod/center link/tie rod; position or replace as needed.	Unit 3-B, Job Sheet 2 – Repair or replace steering knuckle assembly.
5. Check and adjust wheel stops.	Unit 3-B, Job Sheet 2 – Repair or replace steering knuckle assembly. Unit 3-B, Job Sheet 3 – Inspect and replace tie rod ends.
6. Inspect idler arm, bearings and bushings; replace as needed.	Unit 3-B, Job Sheet 2 – Repair or replace steering knuckle assembly. Unit 3-B, Job Sheet 3 – Inspect and replace tie rod ends.
7. Lubricate steering linkage joints as needed.	Not covered. (see MAVCC's Diesel Preventive Maintenance publication)
B. Suspension Systems Diagnosis and Repair	
1. Inspect front axles, U-bolts, and nuts; determine needed action.	Unit 1-C, Job Sheet 1 – Inspect front suspension components.
2. Inspect and service king pin, steering knuckle bushings, locks, bearings, seals, and covers; determine needed action.	Unit 3-B, Job sheet 2 – Repair or replace steering knuckle assembly.
3. Inspect shock absorbers, bushings, brackets, and mounts; determine needed action.	Unit 1-C, Job Sheet 2 – Remove and replace front spring suspension components.
4. Inspect leaf springs, center bolts, clips, eye bolts and bushings, shackles, slippers, insulators, brackets, and mounts; determine needed action.	Unit 1-C, Job Sheet 1 – Inspect front suspension components.
5. Inspect torque arms, bushings, and mounts; determine needed action.	Unit 1-C, Job Sheet 1 – Inspect front suspension components.
6. Inspect axle aligning devices such as radius rods, track bars, stabilizer bars, and related bushings, mounts, shims, and cams; determine needed action.	Unit 1-C, Job Sheet 1 – Inspect front suspension components.
7. Inspect walking beams, center (cross) tube, bushings, mounts, load pads, and saddles/caps; replace as needed.	Unit 1-C, Job Sheet 1 – Inspect front suspension components.

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NATEF Crosswalk

NATEF Tasks	MAVCC Tasks
8. Inspect and test air suspension pressure regulator and height control valves, lines, hoses, dump valves, and fittings; adjust, repair or replace as needed.	Unit 4-C, Job Sheet 2 – Inspect and test an air suspension system, replace the leveling valve, and adjust frame (ride) height.
9. Inspect and test air springs, mounting plates, springs, suspension arms, and bushings; replace as needed.	Unit 4-C, Job Sheet 1 – Inspect, test, and replace an air spring.
10. Measure vehicle frame angle (ride height); determine needed action.	Unit 4-C, Job Sheet 2 – Inspect and test an air suspension system, replace the leveling valve, and adjust frame (ride) height.
11. Diagnose rough ride problems; determine needed action.	Unit 2-A, Job Sheet 1 – Diagnose unusual tire wear patterns, check tire pressure, and measure and match tires. Unit 2-A, Job Sheet 2 – Diagnose tire/wheel vibration, inspect mounting hardware, and check tire/wheel runout and balance. Unit 3-B, Job Sheet 4 – Diagnose and trouble-shoot the steering axle assembly.
C. Wheel Alignment Diagnosis, Adjustment, and Repair	
1. Diagnose vehicle wandering, pulling, shimmy, and hard steering problem(s); adjust and repair as needed.	Unit 3-B, Job Sheet 4 – Diagnose and trouble-shoot the steering axle assembly.
2. Check camber and KPI/SAI (king pin inclination/steering axis inclination); determine needed action.	Unit 5-C, Job sheet 2 – Check camber and kingpin inclination; determine needed repairs.
3. Check caster; adjust as needed.	Unit 5-C, Job Sheet 3 – Check caster; adjust or repair as needed.
4. Check toe; adjust as needed.	Unit 5-C, Job Sheet 4 – Check toe; adjust as needed.
5. Check rear axle(s) alignment (thrustline/centerline) and tracking; adjust or repair as needed	Unit 5-C, Job Sheet 5 – Check rear axle alignment; adjust or repair as needed.
6. Diagnose turning/Ackerman angle (toe-out-on-turns) problems; determine needed action.	Not covered.

NATEF Tasks	**MAVCC Tasks**
7. Check front axle alignment (centerline); adjust or repair as needed.	Not covered.
D. Wheels and Tires Diagnosis and Repair	
1. Diagnose unusual tire wear patterns, check tread depth, mismatched tread design; determine needed action.	Unit 2-A, Job Sheet 1 – Diagnose unusual tire wear patterns, check tire pressure, and measure and match tires.
2, Diagnose wheel/tire vibration, shimmy, pounding, hop (tramp) problems; determine needed action.	Unit 2-A, Job Sheet 2 – Diagnose tire/wheel vibration, inspect mounting hardware, and check tire/wheel runout and balance.
E. Frame Service and Repair	
1. Inspect and adjust fifth wheel, pivot pins, bushings, locking jaw mechanisms, and mounting bolts; determine needed action.	Unit 3-A, Job Sheet 3 – Inspect and service fifth wheel assemblies, pintle hitch, kingpin, and trailer plate.
2. Inspect sliding fifth wheel, tracks, stops, locking systems, air cylinders, springs, lines, hoses, and controls.	Unit 3-A, Job Sheet 3 – Inspect and service fifth wheel assemblies, pintle hitch, kingpin, and trailer plate.
3. Inspect frame and frame members for cracks, breaks, distortion, elongated holes, looseness, and damage; determine needed repairs.	Unit 3-A, Job Sheet 2 – Check and inspect vehicle frame alignment.
4. Inspect, install, or repair frame hangers, brackets, and cross members in accordance with manufacturer's recommended procedures.	Unit 3-A, Job Sheet 1 – Inspect and install or repair frame, hangers, brackets, and cross members.
5. Inspect, install, repair or replace pintle hooks and draw bars.	Unit 3-A, Job Sheet 3 – Inspect and service fifth wheel assemblies, pintle hitch, kingpin,and trailer plate.

Diesel Technology: Steering and Suspension

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

SECTION A: CHASSIS, TIRES, AND WHEELS

Unit 1–A: Cab Components

1. Terms and definitions
2. Basic cab designs
3. Optional features on cabs
4. Vehicle identification numbers
5. Parts of a cab exterior
6. Parts of a cab interior
7. Cab instruments and controls
8. Emergency safety equipment located in the cab
9. Types of driver seats
10. Main components of an air-suspended seat
11. Components of seat belts
12. Types of cab mounts
13. Types of cab lifting/tilting mechanisms
14. Safety rules to follow when working on cabs
15. Inspect, test, and adjust cab air suspension components and determine needed repairs
16. Inspect, test, and adjust driver's air seat components and determine needed repairs

Unit 2–A: Tires, Rims, and Wheels

1. Terms and definitions
2. Functions of tires, rims, and wheels
3. Materials used for tires, rims, and wheels
4. Types of tire construction
5. Types of tires
6. Parts of a radial tubeless tire
7. Types of tire damage
8. Radial tire wear conditions
9. Tire matching and mixing

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 2–A: Tires, Rims, and Wheels (cont.)

10. Types of rims
11. Tire and rim sizes
12. Basic types of wheels
13. Mounting hardware for wheels
14. Types of rim and wheel damage
15. Wheel tightening sequences
16. Tire and wheel assembly runout and balancing
17. Safety precautions to follow when servicing tires, rims, and wheels
18. Tire maintenance

19. Diagnose unusual tire wear patterns, check tire pressure, and measure and match tires
20. Diagnose tire/wheel vibration, inspect mounting hardware, and check tire/wheel runout and balance

Unit 3–A: Chassis Components

1. Terms and definitions
2. Basic chassis components
3. Parts of a frame assembly
4. Frame construction
5. Frame reinforcements
6. Common procedures performed on frames
7. Guidelines for working on frames
8. Things to check on frames
9. Frame fasteners
10. Causes of stress leading to frame damage
11. Practices to follow in frame repairs
12. Basic procedure for checking alignment
13. Purpose of a fifth wheel
14. Basic types of fifth wheel mounting plates
15. Basic types of fifth wheel locking mechanisms
16. Main components of a typical fifth wheel
17. Parts of a trailer

18. Inspect and install or repair frame, hangers, brackets, and cross members
19. Check and inspect vehicle frame alignment
20. Inspect and service fifth wheel assemblies, pintle hitch, kingpin, and trailer plate
21. Couple and uncouple fifth wheel

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

SECTION B: STEERING

Unit 1–B: Steering Column and Manual Steering Gear

1. Terms and definitions
2. Purposes of a steering column and steering gear assembly
3. Basic types of steering columns
4. Parts of a standard steering column and manual steering gear assembly
5. Parts of a tilt/telescoping steering column assembly
6. Parts of a universal joint
7. Basic types of manual steering gears
8. Operation of manual steering gears
9. Common problems or complaints on manual steering gears
10. Common adjustments made on manual steering gears
11. Specialty tools used for work on steering systems
12. Common lubricants used in steering gear assemblies
13. Diagnose and troubleshoot problems on the steering column and steering gear assembly
14. Remove steering wheel, inspect, repair, or replace to proper alignment position
15. Remove, disassemble, and remount the steering gear assembly
16. Perform steering gear adjustments
17. Inspect and replace pitman arm on steering gear assembly
18. Inspect and replace steering u-joints

Unit 2–B: Power Steering Systems

1. Terms and definitions
2. Purposes of power steering systems
3. Basic components of a power steering assembly
4. Basic differences between manual steering and power steering
5. Common types of power steering systems
6. Parts of a integral power steering assembly
7. Parts of a semi-integral power steering assembly

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 2–B: Power Steering Systems (cont.)

8. Power steering gear and valve operation flow for right turn, neutral position, and left turn steering maneuvers
9. Common types of lubricants used in power steering systems
10. Types of lines used on power steering assemblies
11. Basic types of power steering reservoirs
12. Types of hydraulic pumps used on power steering systems
13. Means of mounting power steering pumps
14. Common pump problems and possible causes
15. Diagnose, test, and troubleshoot problems on a power steering system
16. Remove and repair/replace power steering gear
17. Rebuild power steering gear
18. Remove and replace power steering pump; adjust belt if used
19. Inspect, clean, disassemble, and rebuild power steering pump; replace worn parts
20. Test and repair/replace flow control/pressure relief valve(s) on power steering pump
21. Fill and bleed the power steering system

Unit 3–B: Steering Axle Components

1. Terms and definitions
2. Steering axle components
3. Steering linkage
4. Parts of a steering knuckle assembly
5. Lubricants used on steering axle components
6. Typical steering axle problems and causes
7. Purposes of wheel bearings
8. Parts of a wheel bearing
9. Wheel bearing defects
10. Guidelines for servicing wheel bearings
11. Guidelines for adjusting wheel bearings
12. Purposes of wheel seals
13. Types of wheel seals
14. Guidelines for installing wheel seals
15. Select wheel bearings and seals
16. Remove, inspect, clean, replace, and adjust wheel bearings and seals
17. Repair or replace a steering knuckle assembly
18. Inspect and replace tie rod ends
19. Diagnose and troubleshoot the steering axle assembly

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

SECTION C: SUSPENSION

Unit 1–C: Front Suspension

1. Terms and definitions
2. Purposes of front suspension
3. Front suspension components
4. Functions of front suspension components
5. Basic designs of springs
6. Types of front spring assembly ends
7. Dimensions and load ratings of spring assemblies
8. Types of spring eyes
9. Shapes of u-bolts
10. Dimensions of u-bolts
11. Identification and measurement of shock absorbers
12. Inspect front suspension components
13. Remove and replace front spring suspension components

Unit 2–C: Rear Spring Suspension

1. Terms and definitions
2. Purposes of rear suspension
3. Types of springs
4. Rear suspension components
5. Functions of rear spring suspension components
6. Types of rear spring assembly ends
7. Dimensions required for ordering spring assemblies
8. Load rating of spring assemblies
9. Failure of spring assemblies
10. Inspect rear spring suspension components
11. Replace rear spring suspension components

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 3–C: Rear Beam Suspension

1. Terms and definitions
2. Purposes of rear beam suspension
3. Basic models of rear beam suspensions
4. Basic beam components
5. Functions of basic components of rear beam suspensions
6. Operation of rear beam suspension models and components
7. Inspect rear beam suspension components

Unit 4–C: Rear Air Suspension

1. Terms and definitions
2. Purposes of rear air suspension
3. Air suspension components
4. Functions of air suspension components
5. Types of air springs
6. Parts of an air spring
7. Procedure for identifying appropriate replacement air springs
8. Basic valves used on rear air suspensions
9. Air ports of a leveling valve
10. Common causes of air spring failures
11. Inspect, test, and replace an air spring
12. Inspect and test an air suspension system, replace the leveling valve, and adjust frame (ride) height

Unit 5–C: Vehicle Alignment

Related Information: What the Student Should Know

1. Terms and definitions
2. Purposes of vehicle alignment
3. Required times to perform front wheel alignment
4. Toe-in and toe-out
5. Caster
6. Camber
7. Kingpin inclination
8. Maximum turning angle
9. Turning radius angle (Ackermann angle)
10. Axle alignment
11. Pinion angle adjustment
12. Minor and a major front wheel alignment

Application: What the Student Should Be Able to Do

13. Perform pre-alignment checks
14. Check camber and kingpin inclination; determine needed repairs
15. Check caster; adjust or repair as needed
16. Check toe; adjust as needed
17. Check rear axle alignment; adjust or repair as needed
18. Measure and adjust pinion angle

Basic Skills Icons and Classifications

To assist teachers and students in identifying and documenting where academic and workplace skills are being taught, MAVCC has adopted a system that uses icons and a list of specific tasks to identify the skill or skills that are used in each focus assignment, assignment sheet, and job sheet.

A matrix for each of the ten broad skill areas has been included in this edition and reflects key elements from *What Work Requires of Schools: A SCANS Report for America 2000*, a 1991 study by the U.S. Department of Labor; *Workplace Basics: The Skills Employers Want*, a three-year study conducted jointly by the American Society for Training and Development (ASTD) and the United States Department of Labor (DOL); and other national and state sources.

Each of the ten broad skill areas—reading, writing, mathematics, science, oral communication, interpersonal or relating, critical thinking, employability, social studies, and technology—is represented by the icon presented below.

Reading Skills

- Reading Comprehension
- Research/Reference
- Functional Reading

Writing Skills

- Language
- Composition
- Research
- Functional Writing

Math Skills

- Operation and Calculation
- Math Application
- Data Analysis and Display
- Functional Math

Basic Skills Icons and Classifications

Science Skills

- General Science
- Life Science
- Physical Science
- Earth Science

Oral Communication Skills

- Oral Presentation
- Listening
- Interactive Communication

Interpersonal or Relating Skills

- General Relating
- Teamwork/Cooperation
- Leadership/Influence

Critical Thinking Skills

- Cognitive Activities

Employability Skills

- Job Search/Selections
- Job Acquisition/Development
- Resource Management
- Job Safety

Social Studies Skills

- Information Analysis
- Social Studies Application
- Functional Social Studies

Technology Skills

- Selection
- Application
- Maintenance/Troubleshooting

Basic Skills Icons and Classifications

When an activity involving one of these basic skills is identified, the corresponding icon is placed under the evaluation criteria of the assignment sheet or job sheet. Skills training is further defined by classifying specific skills that are required. (See skills list that may be found on each basic skills matrix.)

Example:

Unit 3-B **Steering Axle Components**

Objective 15 **Assignment Sheet 1—Select Wheel Bearings and Seals**

Name ______________________ Overall Rating ________

Date ______________________

Evaluation Criteria	**Rating**
• Directions are followed	____
• Questions are answered correctly	____

Basic Skills

Reading Critical Thinking

Introduction An important skill in the service of brakes and wheel assemblies is the replacement of bearings and seals. There are numerous sizes and designs of seals and bearings, but to do their job properly the installed seals and bearings must be the correct parts for the vehicle. This assignment will provide you with practice in selecting those parts.

Directions Your instructor will assign you one or more vehicles, either actual vehicles in your facility or vehicles identified by make and model. Use resources available in your shop to determine the following information about the wheel bearings and seals for the assigned vehicles.

1. Front Wheels
   a. Bearings or bearing set part number(s) ______________________
   ____
   b. Recommended lubricant ______________________
   c. Seal part number ______________________
   d. Seal material ______________________
   e. Number of seal pieces ______________________
2. Rear Wheels
   a. Bearings or bearing set part number(s) ______________________
   ____
   b. Recommended lubricant ______________________
   c. Seal part number ______________________
   d. Seal material ______________________
   e. Number of seal pieces ______________________

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Section A: Chassis, Tires, and Wheels
Unit 1-A: Cab Components

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
15	Inspect, test, and adjust cab air suspension components and determine needed repairs (J.S. 1)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Locate resources Use in-book reference tools
				Functional reading	Interpret forms and records Follow written instructions Use content area vocabulary
		✎	Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Identify critical elements/issues Define a problem Apply a problem-solving model Analyze/synthesize information Draw conclusions Devise a solution
		🧢	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
16	Inspect, test, and adjust driver's air seat components and determine needed repairs (J.S. 2)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Locate resources Use in-book reference tools
				Functional reading	Interpret forms and records Follow written instructions Use content area vocabulary
		✎	Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Identify critical elements/issues Define a problem Apply a problem-solving model Analyze/synthesize information Draw conclusions Devise a solution
		🧢	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

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Basic Skills Matrix

Unit 2-A: Tires, Rims, and Wheels

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
19	Diagnose unusual tire wear patterns, check tire pressure, and measure and match tires (J.S. 1)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Locate resources Use in-book reference tools
				Functional reading	Interpret forms and records Follow written instructions Use content area vocabulary
		✏	Writing	Functional writing	Complete forms and records
		💡	Critical thinking	Cognitive activities	Identify critical elements/issues Define a problem Identify underlying causes Apply a problem-solving model Draw conclusions Devise a solution
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
20	Diagnose tire/ wheel vibration, inspect mounting hardware and check tire/wheel runout and balance (J.S. 2)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Interpret forms and records Follow written instructions Use content area vocabulary
		✏	Writing	Functional writing	Complete forms and records
		💡	Critical thinking	Cognitive activities	Identify critical elements/issues Define a problem Identify underlying causes Apply a problem-solving model Analyze/synthesize information Draw conclusions Devise a solution
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem Deal effectively with customers/clients

Unit 3-A: Chassis Components

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
18	Inspect and install or repair frame, hangers, brackets, and cross members (J.S. 1)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✏	Writing	Functional writing	Complete forms and records
		💡	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions Devise a solution
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
19	Check and inspect vehicle frame alignment (J.S. 2)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✏	Writing	Functional writing	Complete forms and records
		💡	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions Devise a solution
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Basic Skills Matrix

Unit 3-A: Chassis Components (continued)

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
20	Inspect and service fifth wheel assemblies, pintle hitch, kingpin, and trailer plate (J.S. 3)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Locate resources Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
			Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions Devise a solution
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
21	Couple and uncouple fifth wheel (J.S. 4)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Locate resources Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
			Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions Devise a solution
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Section B: Steering
Unit 1-B: Steering Column and Manual Steering Gear

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
13	Diagnose and troubleshoot problems on the steering column and steering gear assembly (J.S. 1)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✏	Writing	Functional writing	Complete forms and records
		💡	Critical thinking	Cognitive activities	Identify critical elements/issues Identify underlying causes Apply a problem-solving model Analyze/synthesize information Draw conclusions Devise a solution
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem Deal effectively with customers/ clients/patients
14	Remove steering wheel, inspect, repair, or replace to proper alignment position (J.S. 2)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✏	Writing	Functional writing	Complete forms and records
		💡	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Basic Skills Matrix

Unit 1-B: Steering Column and Manual Steering Gear (continued)

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
15	Remove, disassemble, and remount the steering gear assembly (J.S. 3)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
			Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
16	Perform steering gear adjustments (J.S. 4)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
			Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Unit 1-B: Steering Column and Manual Steering Gear (continued)

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
17	Inspect and replace pitman arm on steering gear assembly (J.S. 5)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✎	Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
18	Inspect and replace steering U-joints (J.S. 6)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✎	Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Basic Skills Matrix

Unit 2-B: Power Steering Systems

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
15	Diagnose, test, and troubleshoot problems on a power steering system (J.S. 1)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✎	Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem Deal effectively with customers/ clients
16	Remove and repair/replace power steering gear (J.S. 2)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✎	Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Unit 2-B: Power Steering Systems (continued)

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
17	Rebuild power steering gear (J.S. 3)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✏	Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
18	Remove and replace power steering pump; adjust belt if used (J.S. 4)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✏	Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Basic Skills Matrix

Unit 2-B: Power Steering Systems (continued)

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
19	Inspect, clean, disassemble, and rebuild power steering pump; replace worn parts (J.S. 5)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
			Writing	Functional writing	Complete forms and records
			Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
20	Test and repair/replace flow control/pressure relief valve(s) on power steering pump (J.S. 6)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
			Writing	Functional writing	Complete forms and records
			Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Unit 2-B: Power Steering Systems (continued)

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
21	Fill and bleed the power steering system (J.S. 7)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
			Writing	Functional writing	Complete forms and records
			Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Basic Skills Matrix

Unit 3-B: Steering Axle Components

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
16	Select wheel bearings and seals (A.S. 1)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions
		?	Critical thinking	Cognitive activities	Collect/record information
17	Remove, inspect, clean, replace, and adjust wheel bearings and seals (J.S. 1)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
			Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
18	Repair or replace steering knuckle assembly (J.S. 2)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
			Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Unit 3-B: Steering Axle Components (continued)

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
19	Inspect and replace tie rod ends (J.S. 3)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
			Writing	Functional writing	Complete forms and records
			Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
20	Diagnose and troubleshoot the steering axle assembly (J.S. 4)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Interpret graphics and symbols Use content area vocabulary
			Writing	Functional writing	Complete forms and records
			Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Basic Skills Matrix

Section C: Suspension
Unit 1-C: Front Suspension

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
12	Inspect front suspension components (J.S. 1)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
			Writing	Functional writing	Complete forms and records
			Critical thinking	Cognitive activities	Identify critical elements/issues Define a problem Identify underlying causes Apply a problem-solving model Analyze/synthesize information Draw conclusions
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
13	Remove and replace front spring suspension components (J.S. 2)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
			Writing	Functional writing	Complete forms and records
			Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Unit 2-C: Rear Spring Suspension

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
10	Inspect rear spring suspension components (J.S. 1)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✏	Writing	Functional writing	Complete forms and records
		💡	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
11	Replace rear spring suspension components (J.S. 2)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✏	Writing	Functional writing	Complete forms and records
		💡	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Basic Skills Matrix

Unit 3-C: Rear Beam Suspension

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
7	Inspect rear beam suspension components (J.S. 1)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
			Writing	Functional writing	Complete forms and records
			Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Unit 4-C: Rear Air Suspension

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
11	Inspect, test, and replace an air spring (J.S. 1)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✒	Writing	Functional writing	Complete forms and records
		💡	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
12	Inspect and test an air suspension system, replace the leveling valve, and adjust frame (ride) height (J.S. 2)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✒	Writing	Functional writing	Complete forms and records
		💡	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Basic Skills Matrix

Unit 5-C: Vehicle Alignment

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
13	Perform pre-alignment checks (J.S. 1)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✎	Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Collect/record information Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
		👷	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
14	Check camber and kingpin inclination; determine needed repairs (J.S. 2)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✎	Writing	Functional writing	Complete forms and records
		?	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
		👷	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Unit 5-C: Vehicle Alignment (continued)

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
15	Check caster; adjust or repair as needed (J.S. 3)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✏	Writing	Functional writing	Complete forms and records
		💡	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
16	Check toe; adjust as needed (J.S. 4)	📚	Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Research/ reference	Use in-book reference tools
				Functional reading	Follow written instructions Use content area vocabulary
		✏	Writing	Functional writing	Complete forms and records
		💡	Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
		⛑	Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Basic Skills Matrix

Unit 5-C: Vehicle Alignment (continued)

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
17	Check rear axle alignment; adjust or repair as needed (J.S. 5)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Functional reading	Follow written instructions Interpret graphics and symbols Use content area vocabulary
			Writing	Functional writing	Complete forms and records
			Math	Operation and calculation	Solve formulae and equations
				Math application	Apply geometry principles
			Critical thinking	Cognitive activities	Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem
18	Measure and adjust pinion angle (J.S. 6)		Reading	Reading comprehension	Gain factual information Analyze cause and effect Draw conclusions
				Functional reading	Follow written instructions Use content area vocabulary
			Writing	Functional writing	Complete forms and records
			Math	Math application	Apply geometry principles
			Critical thinking	Cognitive activities	Collect/record information Identify critical elements/issues Apply a problem-solving model Analyze/synthesize information Draw conclusions
			Employability	Job acquisition/ development	Master specific job task/procedure Develop self-confidence/esteem

Tools, Equipment, and Materials List

Alphabetical list of tools, equipment, and materials

Air chuck, clip-on
Alignment equipment procedure manual
Anti-seize compound
Balancer, dynamic
Balance weights
Bar stock, straight, (3/8 x 1-1/2), 9-foot length
Bushing driver set
Camber/caster gauges and turntables
Carpenter's framing squares, 2
C-clamps, 2
Chalk
Cutting torch
Drill set
Flow control/pressure relief valves to be worked on
Front suspension to be worked on
Front wheel assembly to be worked on
Hand tools, technician's common set
Jack, hydraulic floor
Jack stands
Job tickets/work orders—blank forms
Machinist's square
Pencil
Pi tape (or other device for checking tire match)
Pitman arm puller
Plumb bobs, 2
Power steering analyzer
Power steering fluid
Power steering gear to be worked on
Power steering pump to be worked on
Power steering reservoir filter, new
Power steering system to be worked on
Power steering tester, hydraulic
Pry bar
Reamer set
Rear air suspension to be worked on
Rear beam suspension to be worked on
Rear spring suspension to be worked on
Ruler, steel
Scribe
Service manuals
Soapstone
Spirit level or inclinometer

Steering column to be checked and adjusted
Steering gear to be adjusted
Steering gear assembly, manual, to be checked and adjusted
Steering wheel to be worked on
Steering wheel puller
Tape measure
Tire pressure gauge
Tire tread depth gauge
Toe-in gauge
Trammel bar
Vehicle needing alignment checked
Vehicle with cab air suspension
Vehicle with air seats
Washer, high pressure
Water, soapy
Wheel balancing machine
Wheel chocks
Wheel dolly
Wood block
Wrench, air impact
Wrench, torque

Note: Additional tools, equipment, and materials may be required by the service manual or instructor.

Unit 1-A Cab Components

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 1A–3

Written Test 1A–7

Answers to Written Test 1A–17

Learning Activity Sheet 1A–19

Transparency Masters

1—Basic Cab Designs 1A–21
2—Parts of a Cab Exterior 1A–23
3—Parts of a Cab Interior 1A–25

Student Components

Student Page

Objective Sheet 1A–3

Information Sheet 1A–5

Job Sheets

1—Inspect, Test, and Adjust Cab Air Suspension Components and Determine Needed Repairs 1A–19
2—Inspect, Test, and Adjust Driver's Air Seat Components and Determine Needed Repairs 1A–23

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Use sales brochures and various vehicles available in the shop to point out the basic differences between the two types of cabs (conventional and COE). Discuss the advantages and disadvantages of working on each type.
- Show examples of the optional features that may be used on cabs (sleepers, appliances, etc.). Discuss which, if any, the technician may be required to work on.
- Have students locate the vehicle identification numbers (VIN) for various vehicles available in the shop. Discuss the types of information that can be obtained from these numbers.
- Have students identify the common parts of a cab exterior and interior (including instruments and gauges) on various vehicles available in the shop. Also have them identify any unusual or new features.
- Show examples of the emergency safety equipment located in the cab. Show the different types of warning devices that may be used.
- Discuss the components of seat belts and the most common types of repairs required on seat belts.
- Demonstrate the correct procedures for lifting and tilting cabs required before technicians can work on the engines of the different vehicles. Stress the safety precautions that must be followed when working on or around cabs.
- Make sure that vehicles with cab air suspension and air seats are available for students to use when performing Job Sheets 1 and 2.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *Freightliner FLA COE & FLD Conventional Service Manual (Sections 17, 18, and 22).* Portland, OR: Freightliner Corporation.
- *Kenworth Operator's Manual (KW1466).* Kirkland, WA: Kenworth Truck Company/a division of PACCAR, September 1992.

- *1994-95 Recommended Maintenance Practices Manual.* Alexandria, VA: The Maintenance Council.
- Norman, Ian Andrew, Robert Scharff, and John A. Corinchock. *Heavy Duty Truck Systems,* 2nd edition. Albany, NY: Delmar Publishers, 1996.
- *Peterbilt Maintenance Manual (for Models 379, 377, 375, 357, and 355) (Catalog #5290).* Newark, CA: Peterbilt Motors Company, 1987.
- Schultz, Erich J. *Diesel Equipment I and II.* New York: McGraw-Hill Book Company, 1982.
- *Truck Driver Handbook (C0880).* Alexandria, VA: American Trucking Associations, 1992.
- *Truck Systems Design Handbook.* Warrendale, PA: Society of Automotive Engineers, Inc., 1992.

Suggested Supplemental Resources

Print Media

- *MH Cab Repair* service manual (17-100.5). Available from your local Mack Truck service center or contact:

  Mack Trucks, Inc.
  2100 Mack Blvd.
  P.O. Box M
  Allentown, PA 18105-5000
  1-610-439-3011

Electronic Media

- *Tilt Procedure for Modular Cab,* 15-minute videotape. (SEVN9101) (1976) Available from your local CAT dealer or write the following for more information:

  Caterpillar Service Training
  600 W. Washington St., Bldg. JJ
  East Peoria, IL 61630

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the related to cab components with their definitions.

1. Cab
2. Cab-over-engine (COE)
3. Clearance (marker) lights
4. Fairing
5. Fascia
6. Glider kit
7. Reflectors
8. Sleeper cab
9. Tilting

_____ a. New cab and chassis components that are used to replace damaged components

_____ b. Type of cab design in which engine is directly under cab

_____ c. Flexible material commonly used as a bumper cover

_____ d. Process of raising the cab on a cabover design to a partial or full open position

_____ e. The driver-passenger-carrying compartment

_____ f. Glass or plastic prism lenses that reflect light

_____ g. Small amber and red lights attached to the cab and trailer to indicate overall clearance at night

_____ h. Type of cab that contains an optional bed unit for sleeping

_____ i. Member or structure whose primary function is to produce a smooth outline and to reduce drag

Objective 2

Distinguish between the two basic cab designs by placing a:

C — next to conventional cab designs
COE — next to cab-over-engine designs

_____ a. Offers driver a smoother ride and more protection because frame and engine are out front.

_____ b. Provides driver better access to and more room for sleeper.

_____ c. Allows easier access to transmission.

_____ d. Shorter wheelbase allows for easier handling in traffic.

_____ e. Offers technician easier access to engine.

Written Test

Objective 3

Describe two optional features on cabs.

a. ____

____

b. ____

____

Objective 4

Complete statements concerning vehicle identification by filling in the blanks with the correct answers.

a. Vehicle identification numbers are numbers required by law which are assigned to vehicles by manufacturers primarily for ____________________ purposes.

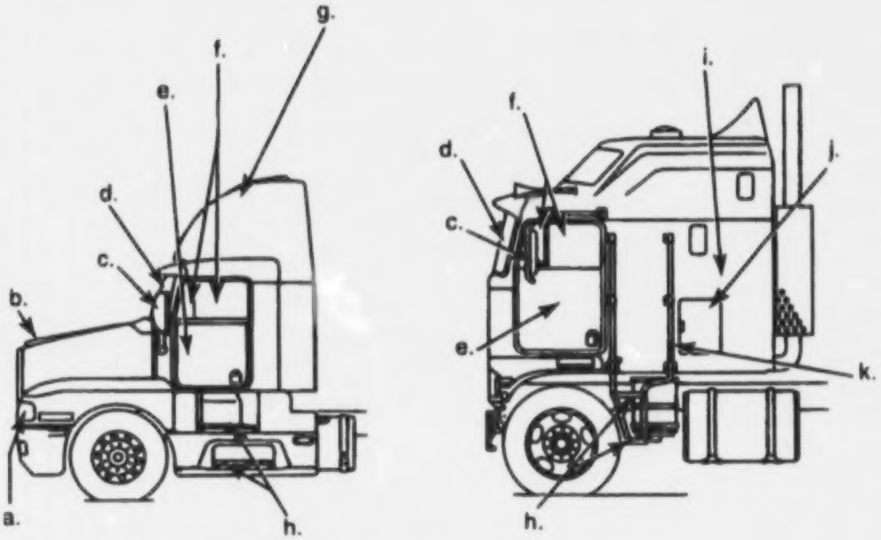
b. VIN consists of ____________________ digits made up of a combination of numbers and letters.

c. VIN identify the model year, manufacturing plant, and ____________________.

d. VIN are located in various places near the ____________________.

Objective 5

Identify parts of a cab exterior. Write your answers on the blanks provided on the next page.

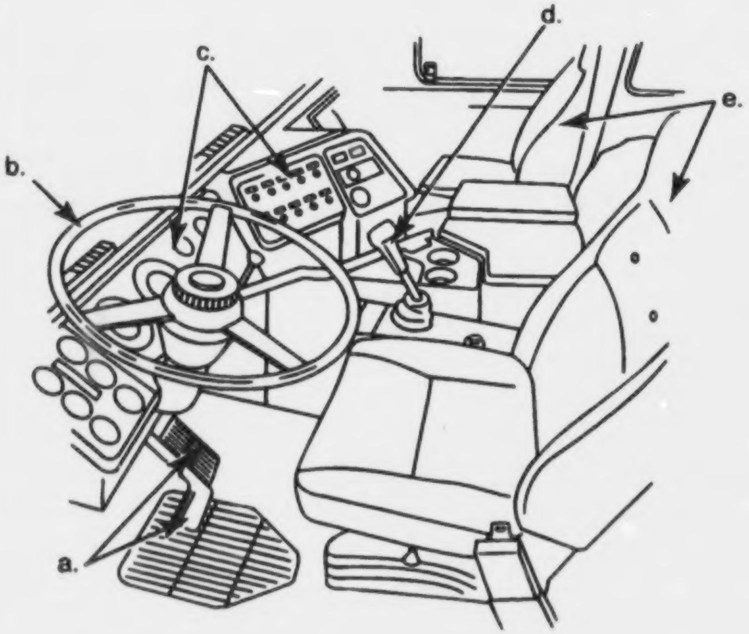


Courtesy of Kenworth Truck Company/PACCAR Inc.

a. ____________________
b. ____________________
c. ____________________
d. ____________________
e. ____________________
f. ____________________
g. ____________________
h. ____________________
i. ____________________
j. ____________________
k. ____________________

Objective 6

Identify parts of a cab interior. Write your answers in the blanks provided.



a. ____
b. ____
c. ____
d. ____
e. ____

Written Test

Objective 7

Match cab instruments and controls with their descriptions. Definitions continue on the next page.

1. Accessory controls
2. Air application pressure gauge
3. Air reservoir pressure gauge
4. Air suspension deflate switch
5. Air tank heat switch
6. Ammeter
7. Axle temperature gauge
8. Brakesaver® switch
9. Electric horn button
10. Engine brake (Jake® brake) switch
11. Engine fan switch
12. Fifth wheel lock switch
13. Fuel tank level gauge
14. Hazard flasher
15. Headlight dimmer switch
16. Heater/air conditioning controls
17. Ignition switch
18. Interaxle differential lock switch
19. Lighting switches
20. Manifold pressure gauge
21. Odometer
22. Oil pressure gauge
23. Oil temperature gauge
24. Parking brake control valve (yellow)
25. Pyrometer
26. Speedometer
27. Tachometer
28. Tilting lever/telescoping ring
29. Tractor park only valve (blue)
30. Trailer air supply valve (red)
31. Trailer brake hand control
32. Transmission temperature gauge
33. Turn signals
34. Visible warning indicator lights
35. Voltmeter
36. Water temperature gauge
37. Windshield wiper/washer controls

_____ a. Indicates temperature of engine coolant

_____ b. Activates all turn signals to flash at once

_____ c. Used to adjust a sliding fifth wheel for better weight distribution

_____ d. Used to help remove moisture and to prevent freezing in the air system

_____ e. Used to set the parking brake for the tractor when it is disconnected from the trailer

_____ f. Include switches for headlights, panel lights, clearance lights, side and tail lights, dome light, trailer clearance lights, and fog lights

_____ g. Measures the engine speed in revolutions per minute (RPM); used for matching driving speed and gear selection

_____ h. Will automatically pop out to set the trailer parking brakes when the tractor parking brakes are set

_____ i. Used primarily to turn on the engine; also has an accessory position to turn on accessory power without turning on the engine

_____ j. Records the miles traveled

_____ k. Shows the temperature of the oil in the transmission

_____ l. Shows the voltage output of the vehicle's electrical system

_____ m. Shows how much air pressure is being applied from the foot brake valve or trailer brake hand valve

_____ n. Include lights for low oil pressure, high water temperature, low air pressure, low coolant, anti-lock problems, and several others

_____ o. Used to turn on blinking indicator lights to let others know the driver is planning to turn the vehicle

_____ p. Indicates temperature of engine oil

_____ q. Allows the steering wheel to be adjusted to improve driver comfort

_____ r. Pulled out to set the parking brake on the tractor

_____ s. Indicates vehicle's speed in miles per hour and kilometers per hour

Objective 8

List three emergency safety equipment located in the cab.

a. ______________________________

b. ______________________________

c. ______________________________

Objective 9

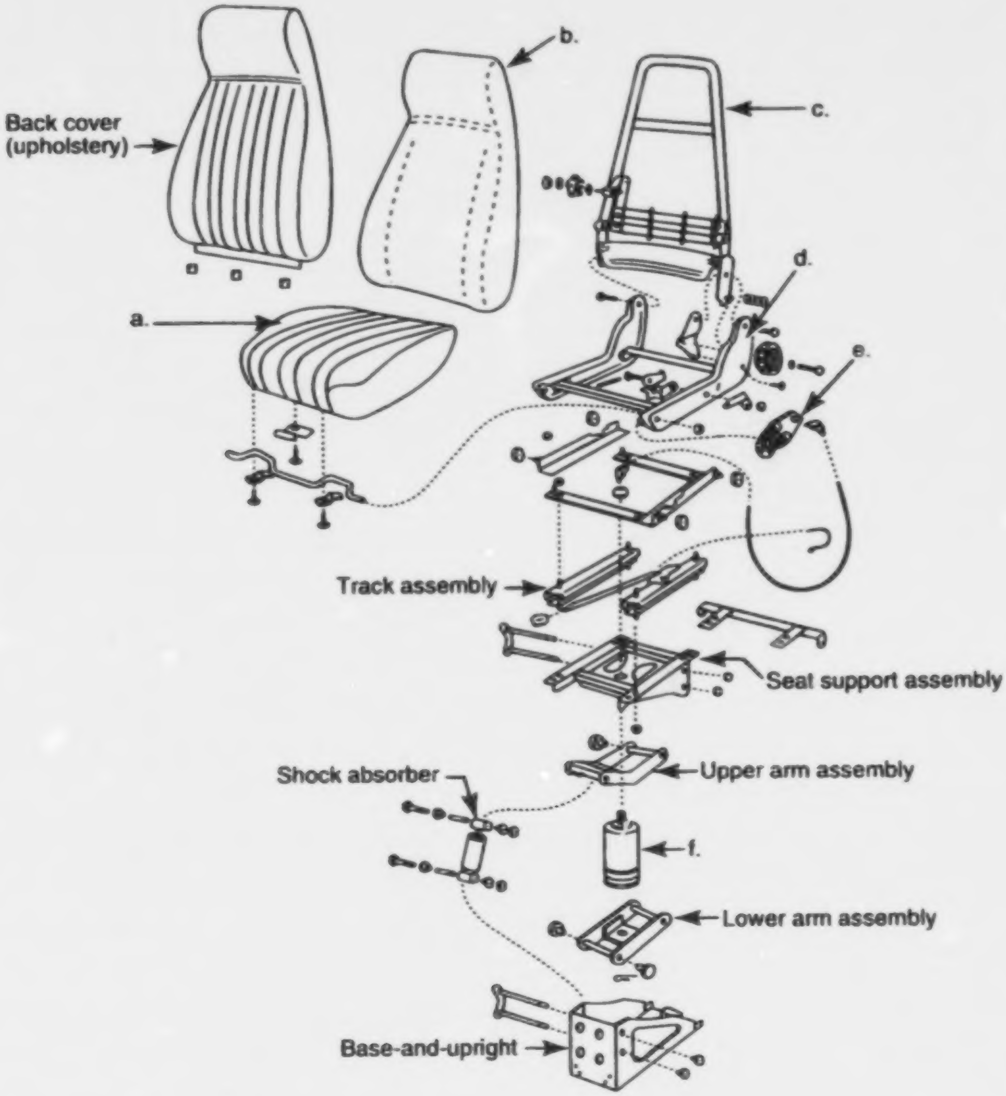
List both types of driver seats

a. ______________________________

b. ______________________________

Written Test

Objective 10 Identify main components of an air-suspended seat. Write your answers in the blanks provided.


b.
Back cover (upholstery)
c.
d.
a.
e.
Track assembly
Seat support assembly
Shock absorber
Upper arm assembly
f.
Lower arm assembly
Base-and-upright

Courtesy of Freightliner Corporation

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

Objective 11

Match components of seat belts with their correct descriptions.

1. Adjustment hardware
2. Attachment hardware
3. Buckle
4. Emergency locking retractor
5. Latch plate (tongue)
6. Tether belt and anchor bracket
7. Three-point seat belt
8. Two-point seat belt
9. Webbing

_____ a. Narrow fabric woven with continuous yarns; very strong but can be damaged when caught in the door and will need replacement

_____ b. Attach buckle end of the seat belt to the cab floor and seat frame; used on suspension seats to prevent excessive movement of the seat

_____ c. Metal or rigid plastic parts that allow for adjusting the size of a seat belt to fit the user

_____ d. Device that stores unused webbing and through which webbing rolls in and out during the fastening process; also contains a locking mechanism so webbing will not continue to roll out during an emergency

_____ e. Is a lap and shoulder belt for pelvic and upper torso restraint

_____ f. Flat, metal piece that inserts into the buckle for fastening

_____ g. Quick-release mechanism which receives the latch plate for fastening

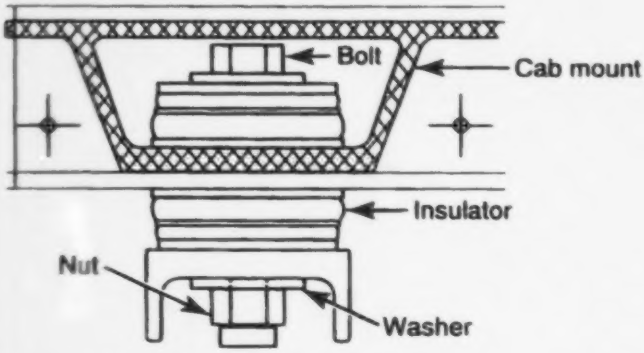
_____ h. Metal parts designed for securing the webbing to the vehicle; is attached in two or three points depending on the type of seat belt

Written Test

Objective 12

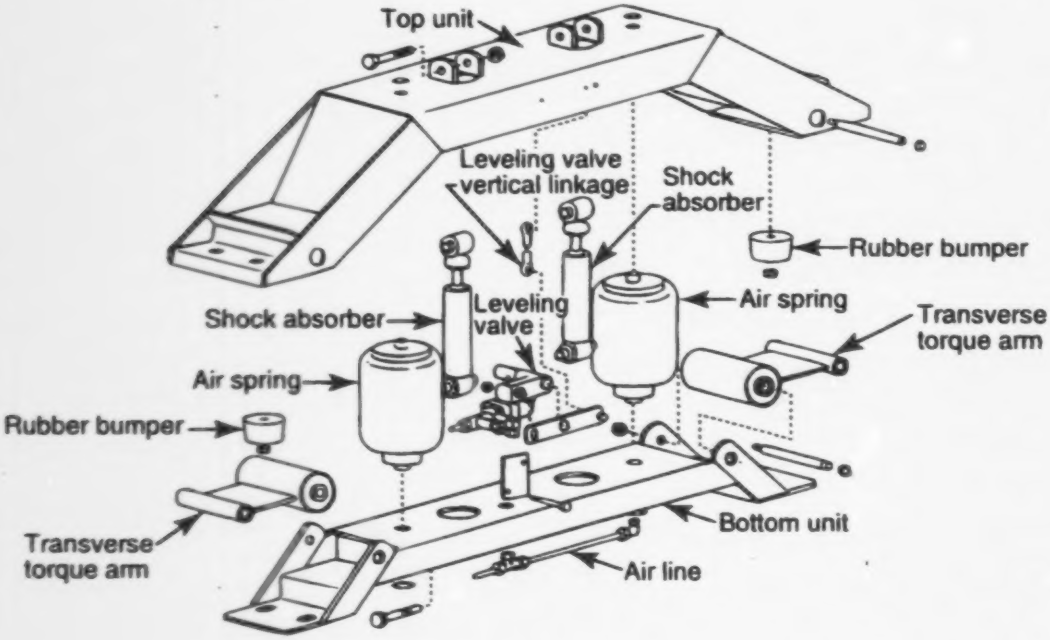
Distinguish between types of cab mounts by placing an "X" next to the illustration of a stationary (solid) cab mount.

_____ a.


Bolt
Cab mount
Insulator
Nut
Washer

Courtesy of Peterbilt Motors Company/PACCAR Inc.

_____ b.


Top unit
Leveling valve vertical linkage
Shock absorber
Rubber bumper
Air spring
Transverse torque arm
Shock absorber
Leveling valve
Air spring
Rubber bumper
Transverse torque arm
Bottom unit
Air line

Courtesy of Freightliner Corporation

Objective 13

List the types of cab lifting/tilting mechanisms.

a. ______________________________

b. ______________________________

Objective 14

Complete statements concerning safety rules to follow when working on cabs by circling the correct answers.

a. (**Always, Never**) jump out of a cab.

b. When getting into and out of the cab, always maintain at least (**two, three**) points of contact with your hands and feet.

c. Before tilting or lifting any hood, make sure the engine is (**running, not running**) and the parking brake has been set.

d. Before tilting a COE cab, make sure the shift lever is in (**first gear, neutral**).

e. Before getting under a COE cab, always make sure the safety lock bar is (**engaged, disengaged**).

f. (**Do, Do not**) bleed the hydraulic system of a COE cab with the cab tilted.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 6
b. 2
c. 5
d. 9
e. 1
f. 7
g. 3
h. 8
i. 4

Objective 2

a. C
b. C
c. COE
d. COE
e. C

Objective 3

Descriptions should include any two of the following:

a. Sleepers
- Consist of bed or bunk beds for drivers' and/or passenger's convenience and comfort when sleeping
- Available on either cab design

b. Appliances
- May include refrigerators, microwaves, and radios for the driver's convenience and comfort when traveling
- Must be secured so they won't move during a sudden stop

c. Special aerodynamic design features
- Used to improve fuel efficiency by reducing wind resistance
- Includes wind deflectors, roof shields, and special side fairing around fuel tanks

d. Heated mirrors—Used to prevent fogging and icing on outside mirrors
e. Cruise control—Used to regulate "cruising" speed

Objective 4

a. Registration or identification
b. 17
c. Vehicle serial number
d. Driver's door

Objective 5

a. Lights
b. Hood
c. Mirror
d. Windshield
e. Door
f. Windows
g. Wind deflector
h. Cab steps
i. Sleeper
j. Baggage door
k. Cab hand holds

Answers to Written Test

Objective 6

a. Pedals
b. Steering wheel and controls
c. Instrument gauges and controls
d. Transmission shift control lever
e. Seat

Objective 7

a. 36
b. 14
c. 12
d. 5
e. 29
f. 19
g. 27
h. 30
i. 17
j. 21
k. 32
l. 35
m. 2
n. 34
o. 33
p. 23
q. 28
r. 24
s. 26

Objective 8

Answers should include any three of the following:

a. Fire extinguisher (multipurpose type)
b. Warning devices (at least 3); several types may be used such as red reflectors, emergency flares, red flags, red reflective triangles, or electric lanterns.
c. Spare fuses
d. Jumper cables
e. First aid kit
f. Telephone

Objective 9

a. Air-suspended seat
b. Spring-suspended seat

Objective 10

a. Seat cushion
b. Back cushion (polyfiller)
c. Upper frame assembly
d. Lower frame assembly
e. Air valve assembly
f. Air spring

Objective 11

a. 9
b. 6
c. 1
d. 4
e. 7
f. 5
g. 3
h. 2

Objective 12

a

Objective 13

a. Manual lift
b. Hydraulic lift

Objective 14

a. Never
b. Three
c. Not running
d. Neutral
e. Engaged
f. Do not

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 9.

Optional

☐ 4. **View** Videotape entitled "Tilt Procedure for Modular Cab."

☐ 5. **Do** Job Sheet 1, "Inspect, Test, and Adjust Cab Air Suspension Components and Determine Needed Repairs."

☐ 6. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 7. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Steps 3 through 5.

☐ 7. **Study** Information Sheet, Objectives 10 and 11.

☐ 8. **Do** Job Sheet 2, "Inspect, Test, and Adjust Driver's Air Seat Components and Determine Needed Repairs."

☐ 9. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 10. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Steps 7 and 8.

☐ 10. **Study** Information Sheet, Objectives 12 through 14.

☐ 11. **Check** With instructor for any additional assignments to be completed.

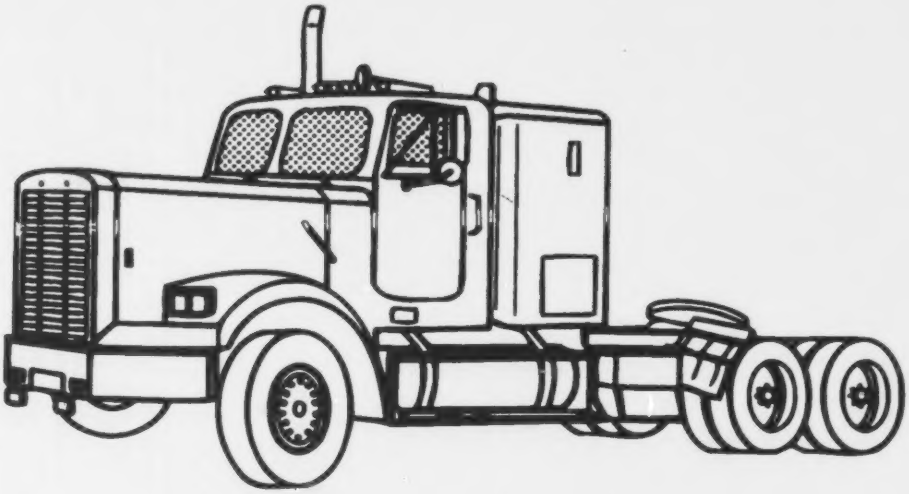
Learning Activities Sheet

☐ 12. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

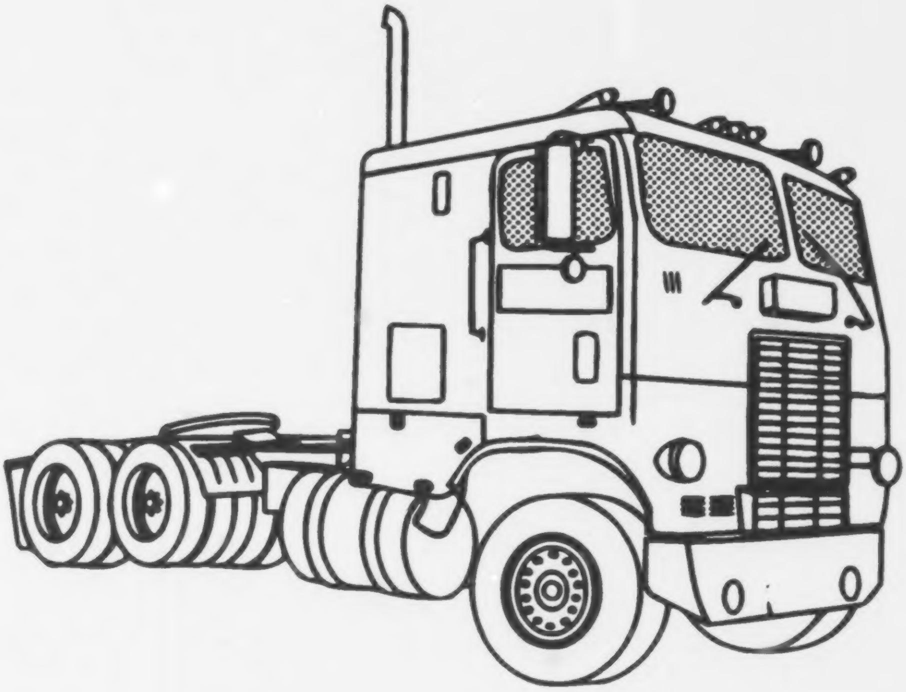
☐ 13. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Basic Cab Designs



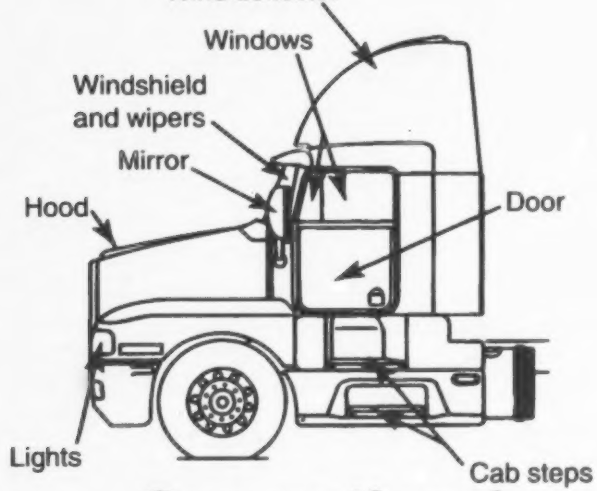
Conventional



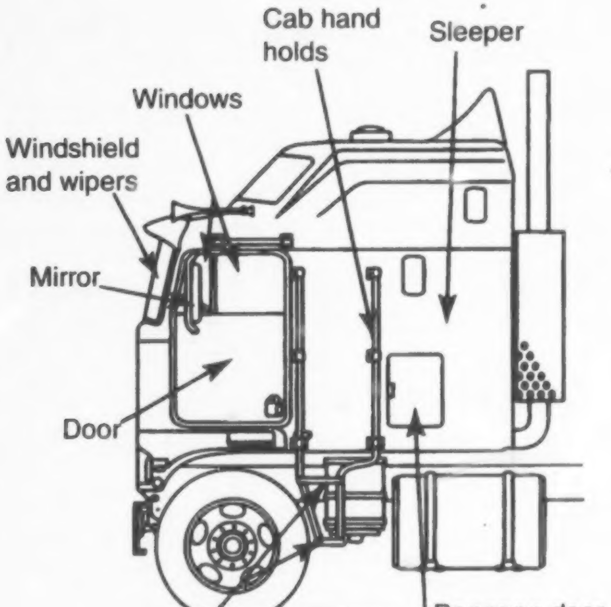
Cab-over-engine

TM 1

Parts of a Cab Exterior


Wind deflector
Windows
Windshield and wipers
Mirror
Hood
Door
Lights
Cab steps

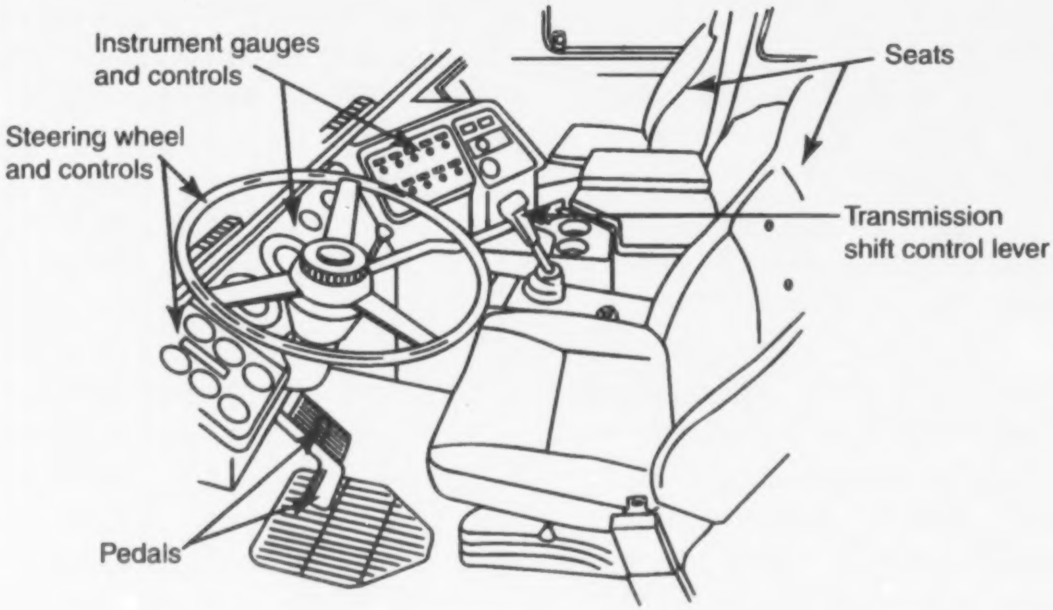
Conventional


Cab hand holds
Sleeper
Windows
Windshield and wipers
Mirror
Door
Baggage door
Cab steps

Cab-over-engine

Courtesy of Kenworth Truck Company/PACCAR Inc.

Parts of a Cab Interior


Instrument gauges and controls
Seats
Steering wheel and controls
Transmission shift control lever
Pedals

Unit Contents

Teacher Page

Teacher Components

Suggested Activities 2A-3
Written Test 2A-11
Answers to Written Test 2A-23
Learning Activities Sheet 2A-27

Transparency Masters

1—Types of Tires 2A-29
2—Parts of a Radial Tubeless Tire 2A-31
3—Radial Wear Conditions 2A-33
4—Radial Wear Conditions (Continued) 2A-35
5—Radial Wear Conditions (Continued) 2A-37
6—Types of Rims 2A-39
7—Parts of a Cast Spoke Wheel 2A-41
8—Parts of a Disc Wheel 2A-43
9—Wheel Tightening Sequences 2A-45
10—Tire Inflation 2A-47

Student Page

Student Components

Objective Sheet 2A-3
Information Sheet 2A-5

Job Sheets

1—Diagnose Unusual Tire Wear Patterns, Check Tire Pressure, and Measure and Match Tires 2A-31
2—Diagnose Tire/Wheel Vibration, Inspect Mounting Hardware and Check Tire/Wheel Runout and Balance 2A-35

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Invite local tire, rim, and wheel distributors or manufacturer representatives to talk to the class about their most common products used on diesel equipment and any new products on the market. Have the distributors/representatives show catalogs of products, as well as samples if possible.

- Show examples of the different types of tires.

  - Bias ply and radial ply

  - Tube type and tubeless

  - Conventional, low aspect/profile, and wide base

  Point out the similarities and differences and the advantages and disadvantages of each. Also discuss specialty tires that may be used in your area, such as logging, agriculture, or heavy equipment tires.

- Cut various old tires so students can identify the various parts of a tire (belts, plies, liner or tube, valve, flap, bead, etc.)

- Show examples of damaged tires, and discuss the most common causes of damage for the different areas—bead, sidewall, crown, or interior.

- Show examples of worn tires, and discuss normal wear and unusual wear patterns. Discuss how wear patterns are used to diagnose alignment or vehicle/equipment problems.

- Demonstrate the various methods used to measure for tire matching. Demonstrate as many methods as possible. Students will perform this task using one method in Job Sheet 1.

- Show examples of the basic types of rims—one-piece and multipiece. Point out the difference between a side ring and a lock ring used on two- or three-piece rims. Have students practice matching rings and rims.

- Discuss how tires and rims are sized. Explain the meanings of the various number and letter designations. Provide examples of tires and rims and have students read the sizes.

- Show examples of cast spoke wheels and disc wheels. Also show the different types of mounting hardware for each type. Make sure students understand the difference between hub-piloted and stud-piloted disc wheels.

- Show examples of rim and wheel damage. Discuss the causes of the damage and what can or cannot be done to repair the damage.
- Have students demonstrate the correct wheel tightening sequences for spoke and disc wheels.
- Demonstrate the correct procedures and equipment to be used for checking runout and balancing. Students will be performing this task in Job Sheet 2 and will need to know the correct procedures and equipment to use.
- Discuss and demonstrate the safety precautions to follow when servicing tires, rims, and wheels. Discuss accidents you have seen, been involved in, or heard about so students will appreciate the seriousness of following safety rules, especially around tires, rims, and wheels. Additional training (beyond what is covered in this unit) will be needed if students will be mounting or dismounting tires.
- Visit a tire shop so students can see the types of jobs involved in servicing tires. Point out the safety equipment and devices used for tire work.
- Show students tires that are underinflated, overinflated, and properly inflated. Have students practice checking various tires' pressures. Discuss how it is often difficult to see if a tire is at the correct pressure; the only way to know for sure is to check it with a tire gauge. Also have them practice measuring the tread depth.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

Suggested Activities

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *Freightliner COE & 120 Conventional Service Manual (Section 13.00).* Portland, OR: Freightliner Corporation, 1989.
- *Heavy Equipment Mechanic.* Stillwater, OK: AGC/CIMC/Oklahoma Department of Vocational and Technical Education, 1985.
- *1994-95 Recommended Maintenance Practices Manual.* Alexandria, VA: The Maintenance Council.
- Norman, Ian Andrew, Robert Scharff, and John A. Corinchock. *Heavy Duty Truck Systems,* 2nd edition. Albany, NY: Delmar Publishers, 1996.

- *Peterbilt Maintenance Manual (for Models 379, 377, 375, 357, and 355) (Catalog #5290)*. Newark, CA: Peterbilt Motors Company, 1987.
- *Radial Tire Conditions Analysis Guide*. Alexandria, VA: The Maintenance Council, 1994.
- Schultz, Erich J. *Diesel Equipment I and II*. New York: McGraw-Hill Book Company, 1982.

Suggested Supplemental Resources

Print Media

- *Accuride Rim/Wheel Safety and Service Manual.* Includes safety, inspection, identification, matching and service information. 60 pages.
- *Rim and Ring Matching Wall Chart.* 19 x 34½ inches

The above are available from:

Accuride Corp.
P.O. Box 40
2315 Adams Lane
Henderson, KY 42420
1-502-826-5000

- *Out of Service Tire Analysis Guide.* (T0110). Deals with tire analysis, maintenance, and repair.
- *Radial Tire Conditions Analysis Guide.* (T0121). Illustrates tire wear patterns and their causes.
- *User's Guide to Wheels and Rims.* (T0410). Guide to wheel and rim maintenance.

The above are available from:

American Trucking Associations
Customer Services Dept.
2200 Mill Road
Alexandria, VA 22314-4677
1-800-ATA-LINE

- *Motor Wheel/Goodyear Training Kit (#RT88-2635).* Consists of the following publications:
  - *Motor Wheel/Goodyear On-Highway Safety and Service Manual (TR89-2538)*
  - *OSHA Demounting and Mounting Procedures for Truck/Bus Tires Service and Safety Wall Chart*
  - *Motor Wheel Installation Procedures and Recommended Torque for Side Wheels and Demountable Rims (TW89-2549)*

- *OSHA Multi-Piece Rim Matching Wall Chart*
- *OSHA Bulletin 3086, 1984*
- *OSHA Rule 1910.177*
- *Motor Wheel/Goodyear Shop Training Program Manual (TR88-2536)*

- *Tire Tracks* (SDF-018) self-paced training module. Available from:

  Freightliner Corporation
  Technical Training Department
  5169 N. Lagoon Avenue
  Portland, OR 97217

- *Wheels, Rims, and Tires* service manual (#15-101). Available from your local Mack Truck service center or contact:

  Mack Trucks, Inc.
  2100 Mack Blvd.
  P.O. Box M
  Allentown, PA 18105-5000
  1-610-439-3011

Electronic Media

- *Servicing Single and Multipiece Wheels* videotape
- *Servicing and Maintaining Disc Wheels* videotape

  The above are available from:

  Accuride Corp.
  P.O. Box 40
  2315 Adams Lane
  Henderson, KY 42420
  1-502-826-5000

- You May Not Get a Second Chance videotape
- Reason Behind the OSHA Rules videotape
- Wheel/Rim Inspection and Cleaning videotape
- WHD-8 Installation and Maintenance videotape

  The above are available from:
  Motor Wheel Corporation
  Marketing Communication Dept.
  4000 Collins Road
  Lansing, MI 48910

- Tire Wear Diagnosis (90-6) videotape (VHS)—GMC Truck. Available from:

  Regan Productions, Inc.
  Service Video Library
  19730 Ralston
  Detroit, MI 48203
  1-313-368-3000

- FOS Tires and Tracks set of 79 slides (FOS5507S-152). Available from:

  Deere & Company
  Distribution Service Center
  P.O. Box 186
  Moline, IL 61266-1086

- *Tire Repair Failure Analysis* videotape (T0300). Learn the causes of tire repair failure, as well as the newest technologies for radial tire repair.

- *Tire Pre-Trip Inspection Guidelines* videotape (T0280). Covers inspection and repair procedures. Defines legally permissible and out-of-service tire conditions.

- *Wheel and Rim Inspection* videotape (T0350). Covers the best maintenance practices for medium- and heavy-duty wheels and rims in accordance with all DOT regulations. Explains differences between hub-piloted and stud-piloted wheel fastening systems.

  The above are available from:

  American Trucking Associations
  Customer Services Dept.
  2200 Mill Road
  Alexandria, VA 22314-4677
  1-800-ATA-LINE

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms with their definitions. Definitions continue on the next page.

1. Aspect ratio
2. Bead chafing
3. Bead seating
4. Capacity
5. Casing
6. Circumferential direction
7. Delamination
8. Demountable rim
9. Disc wheel
10. Dual spacing
11. Grooves
12. Mounting
13. Out-of-balance
14. Pi (π) tape
15. Ply
16. Radial direction
17. Retread
18. Rim clamp
19. Rim well
20. Spacer band
21. Spoke wheel
22. Torque
23. Trajectory
24. Valve slot
25. Valve stem
26. Weathering

_____ a. Separation of layers of rubber

_____ b. Spaces between two adjacent tread ribs or lugs

_____ c. Wear of the bead against the rim

_____ d. Tire size designation that is the ratio of the tire's section height to section width for a specified rim width

_____ e. Tire structure excluding the tread and shoulder

_____ f. Assembling the tire on the rim

_____ g. 360 degrees around the tire

_____ h. Distance from the center of a tire to the center of the other tire in a dual tire arrangement

_____ i. Maximum amount that a tire, rim, or wheel can carry or store; expressed in load (lbs) and cold inflation pressure (psi)

_____ j. Condition that exists when there is an unequal distribution of weight about the axis of rotation

_____ k. Permanent assembly of a disc and a rim for attachment to vehicle hub

_____ l. Positioning of the bead on the rim

_____ m. Rim intended for use on a cast spoke wheel

_____ n. Measuring device used to obtain the circumference of a tire for comparing and matching tires

_____ o. Elongated opening in a multipiece rim that receives the valve stem

_____ p. Metal band that separates two rear demountable rims

_____ q. Layer of rubber-coated parallel cords

_____ r. Protruding part of a tire tube that allows for inflation/deflation of the tube-type tire assembly when properly mounted

_____ s. Casting with multiple spokes that provides a means of attaching a demountable rim to a vehicle

_____ t. From bead to bead

_____ u. Measurement of nut tightness

_____ v. Device used to hold a demountable rim on a spoke wheel

_____ w. Potential path or route that a component may travel during an accident such as the sudden release of pressurized air or explosion

_____ x. To apply and cure new tread on a casing to extend the life of the tire

_____ y. Fine hairline cracks in the sidewall surface of the tire caused by oxidation and other atmospheric conditions

_____ z. Dropped center area of a single-piece rim made to a smaller diameter than the bead seat area of the rim

Objective 2

Distinguish among the functions of tires, rims, and wheel by placing a:

T = next to tire function
R = next to rim function
W = next to wheel function

_____ a. Support the tires and contain the tires' inflation pressures.

_____ b. Support the weight of the vehicle; transfer the load to the road.

_____ c. Transfer the load from the axle to the tires.

Objective 3

State materials used for tires, rims, and wheels in the following blanks.

a. Tires— ______________________________

b. Rims— ______________________________

c. Wheels— ______________________________

Objective 4

Distinguish between types of tire construction by placing a:

B = next to bias ply.
R = next to radial ply.

_____ a. Commonly used because they have less tread distortion, greater fuel efficiency, longer tread wear, and more puncture resistance. They also give the driver more steering control and traction, as well as a smoother ride.

_____ b. Not commonly used on highways.

_____ c. Body plies are laid at right angles to the circumference of the tire and run from bead to bead. The plies are then secured with belts that wrap around the tire's circumference.

_____ d. The body plies overlap and cross on the diagonal from tire bead to tire bead.

Objective 5

Match types of tires with their correct descriptions.

1. Tube type
2. Tubeless
3. Low aspect
4. Wide base

_____ a. More commonly used because they offer several advantages—less weight, reduced parts inventory, improved durability because of less heat, and reduced downtime from punctures

_____ b. Are larger tires and provide increased load capacity

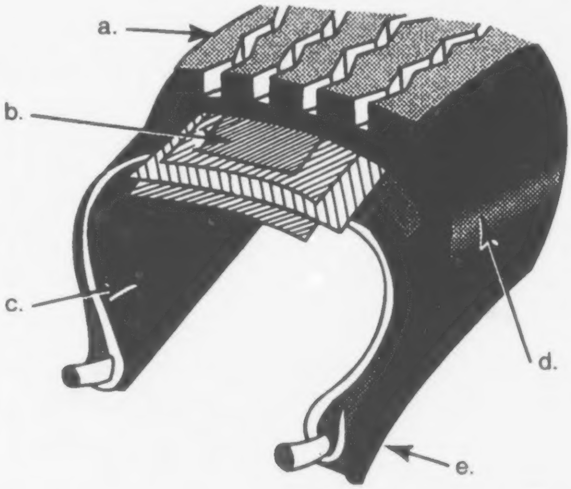
_____ c. Have shorter sidewall heights and wider tread widths than conventional tires

_____ d. Requires a multipiece rim/wheel assembly and is therefore dangerous to mount/demount

Written Test

Objective 6

Identify the parts of a radial tubeless tire. Write your answers in the blanks provided.



a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

Objective 7

List eight types of tire damage.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

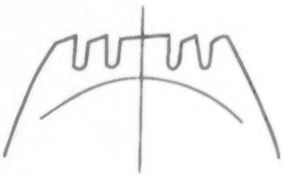
f. ____________________

g. ____________________

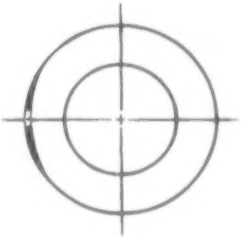
h. ____________________

Objective 8

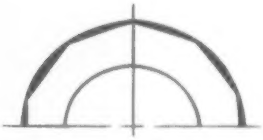
Identify the following radial tire wear conditions. Write your answers in the blanks provided.



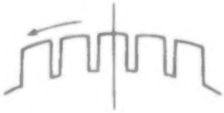
a. ____________________



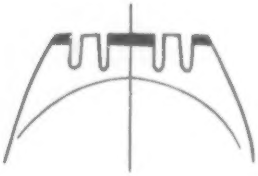
b. ____________________



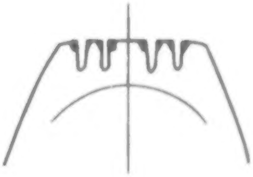
c. ____________________



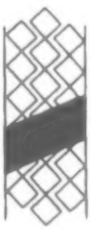
d. ____________________



e. ____________________



f. ____________________



g. ____________________

Written Test

Objective 9

Complete statements concerning tire matching and mixing by filling in the blanks with the correct answers.

a. Do not change wheels or tires without checking the certified ____________ ____________ ____________ rating.

b. When pairing tires in a dual assembly, the tire diameters must not differ by more than ____________ inch or the tire circumference by more than ____________ inch.

c. Better tire and vehicle performance is usually obtained by using tires of the same ____________ and construction.

d. Using tires of different construction will result in loss of steering control and premature ____________ ____________.

Objective 10

Distinguish among types of rims by placing a:

S = next to single-piece rim.
M = next to multipiece rim.

_____ a. Used on tube-type tires.

_____ b. Are dangerous during demounting and mounting process because pieces can come apart with great force.

_____ c. Is a continuous (uninterrupted) assembly.

_____ d. Dropped in center of rim base to allow for mounting.

_____ e. May be two-piece or three-piece.

Objective 11

Complete statements concerning tire and rim sizes by circling the correct answers.

a. Standard tires are sized according to (**tire section width, circumference**) and rim diameter.

b. (**Aspect, Profile**) ratio is also stated for low profile tires.

c. The design rim width is approximately (**50%, 75%**) of the tire width.

d. Most tire sizes have (**two, five**) approved alternative rim widths.

e. Tire size is marked on the (**inside, outside**) surface of a tire, along with the manufacturer's name, style name, and DOT code numbers (required by law) that identify manufacturing plant and date.

f. The Federal Motor Vehicle Safety Standard (FMVSS 120) requires that the rim size, type, and manufacturer's information must be stamped on the (**rim, tire**) and its components.

Written Test

Objective 12

Distinguish between basic types of wheels by placing a:

C = next to cast spoke wheels.
D = next to disc wheels.

_____ a. Consist of a wheel and brake drum assembly installed on the axle and a tire and rim assembly that mounts on the wheel.

_____ b. Consist of a rim and disc welded together.

_____ c. After the tire is mounted on the rim/wheel, the assembly is held in place on the hub with wheel studs and nuts.

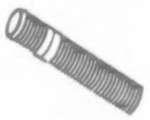
_____ d. Rim clamps and rim (hex) nuts hold the tire and rim assembly in place.

_____ e. There are two basic methods for installing this type of wheel—hub-piloted and stud-piloted.

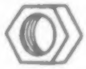
Objective 13

Identify the following mounting hardware for wheels. Write your answers in the blanks provided.

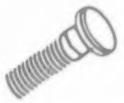
a. Cast spoke wheels



1. ____________

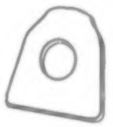


2. ____________

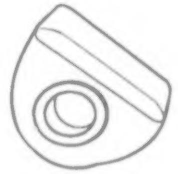


(special shaped head)

3. ____________

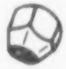


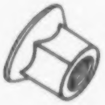
4. ____________



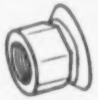
5. ____________

b. Disc wheels—Hub-piloted



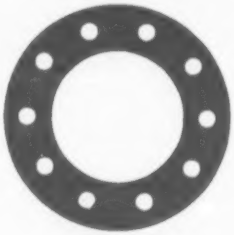


(Light/medium truck)



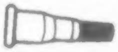
(Heavy-duty truck)

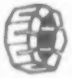
1. ______________ 2. ______________ 3. ______________

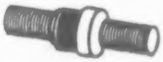


4. ______________

c. Disc wheels—Stud-piloted







1. ______________ 2. ______________ 3. ______________

Objective 14

List four types of rims and wheel damage.

a. ______________________________________

b. ______________________________________

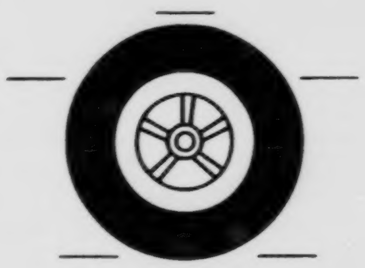
c. ______________________________________

d. ______________________________________

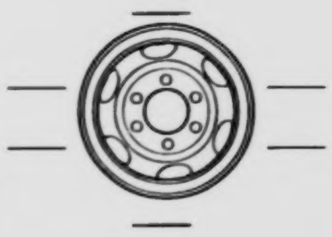
Objective 15

Label wheel tightening sequences for the following types of wheels. Write your answers in the blanks provided.

a. Spoke wheels—Place 1-5 in the appropriate positions.



b. Disc wheels—Place 1-6 in the appropriate positions.



Objective 16

Complete statements concerning tire and wheel assembly runout and balancing by circling the correct answers.

a. (**Lateral, Radial**) runout is a variation in the rotating assembly in a side-to-side direction (wobble).

b. (**Lateral, Radial**) runout is a variation in the radius of the rotating assembly

c. A runout (**gauge, stick**) is commonly used to check runout.

d. Lateral runout should be checked along the tire's (**sidewall, tread**).

e. Radial runout should be checked along the tire's (**sidewall, tread**).

f. Correct excessive runout (**before, after**) checking tire/wheel assembly balance.

g. Out-of-balance rotating assemblies can contribute to driver (**comfort, discomfort**).

h. Rotating assemblies can be balanced in two ways—statically and (**laterally, dynamically**). The goal of both is to obtain an on-center rotating wheel and assembly.

i. If out-of-balance exceeds suggested limits, correct by (**adding, subtracting**) weight to/from the rim or wheel flange, half on each side of the rim or wheel.

j. If a tire/wheel assembly is removed for balancing, be sure to mark the tire/wheel position on the brake drum or hub so it can be reinstalled in (**the same, a rotated**) position.

Objective 17

Distinguish between correct and incorrect safety precautions to follow when servicing tires, rims, and wheels by circling the correct answers.

a. (**Always, Never**) stand in front of or over an inflated tire. Stay out of the trajectory and warn others.

b. (**Always, Never**) block wheel on other side of vehicle before placing jack in position.

c. (**Always, Never**) use a wood block under jack when working on the ground.

d. (**Always, Never**) deflate the tire completely before removing from vehicle.

e. (**Do, Do not**) add air to tire and rim assemblies that have been operated in a seriously underinflated or flat condition (80% or less of recommended pressure).

f. (**Always, Never**) attempt to lift or move heavy tires or wheels without help.

g. (**Always, Never**) make sure that rim parts match properly.

h. (**Always, Never**) check to make sure that the tire diameter matches the rim/wheel diameter.

i. (**Always, Never**) attempt to rework, weld, heat, or braze rim or wheel parts.

j. (**Always, Never**) use a restraining device or cage, clip-on chuck, and remote valve/gauge when inflating a tire.

k. (**Always, Never**) exceed maximum load or inflation pressures.

l. (**Always, Never**) check for proper seating of the bead before removing tire/rim from restraining device.

m. (**Always, Never**) attempt to correct the seating by hammering, striking, or forcing parts while the tire is inflated.

Written Test

Objective 18

Complete statements concerning tire maintenance by circling the correct answers.

a. The most important factor in tire maintenance is proper (inflation, rotation).

b. Proper (inflation, rotation) allows the tread to make full contact with the road for best traction, braking ability, and safety.

c. (Underinflation, Overinflation) causes abnormal tire deflection which builds up heat and causes irregular wear.

d. (Underinflation, Overinflation) causes tire to run hard, is more vulnerable to impacts, and causes irregular wear.

e. Keep both tires in a dual assembly at the same (pressure, age).

f. If significant (high, low) pressure is found, check tire for punctures, valve leakage, or wheel/rim damage.

g. Check tire tread depth periodically. Federal law requires truck tires on front axles to have at least (1/8", 1/16") tread depth.

h. Keep all (water-based, petroleum) products away from tires because they can cause rubber to become soft and spongy.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 7
b. 11
c. 2
d. 1
e. 5
f. 12
g. 6
h. 10
i. 4
j. 13
k. 9
l. 3
m. 8
n. 14
o. 24
p. 20
q. 15
r. 25
s. 21
t. 16
u. 22
v. 18
w. 23
x. 17
y. 26
z. 19

Objective 2

a. R
b. T
c. W

Objective 3

a. Tires—Rubber compounds including nylon, polyester, and other materials for casings and treads; steel for reinforcing piles and belts
b. Rims—Steel or aluminum
c. Wheels—Steel, cast iron, or aluminum

Objective 4

a. R
b. B
c. R
d. B

Objective 5

a. 2
b. 4
c. 3
d. 1

Objective 6

a. Tread
b. Belts
c. Radial ply
d. Sidewall
e. Bead assembly

Objective 7

Any eight of the following

a. Torn beads
b. Kinked or distorted beads
c. Deformed beads
d. Cuts and snags
e. Sidewall separation
f. Chain damage
g. Weathering
h. Impact breaks
i. Petroleum product damage
j. Blisters/bumps

Answers to Written Test

k. Penetrations and road hazards (nails, glass, etc.)
l. Chipping/flaking/chinking tread
m. Excessive wear
n. Groove tracking
o. Belt lift/separation
p. Tread lift/separation
q. Brake skid damage
r. Lug base cracking
s. Liner splice
t. Liner bubbles or blisters
u. Liner cracking
v. Pulled/loose cords

Objective 8

a. Feather wear
b. Eccentric/out-of-round wear
c. Cupping/scallop wear
d. Heal/toe wear
e. Alternate lug wear
f. Erosion/river/channel wear
g. Diagonal wear

Objective 9

a. Gross Vehicle Weight
b. $^1/_4$, $^3/_4$
c. Size
d. Tire wear

Objective 10

a. M
b. M
c. S
d. S
e. M

Objective 11

a. Tire section width
b. Aspect
c. 75%
d. Two
e. Outside
f. Rim

Objective 12

a. C
b. D
c. D
d. C
e. D

Objective 13

a. Cast spoke wheels
   1. Stud
   2. Nut
   3. Bolt
   4. Front rim clamp
   5. Rear rim clamp

b. Disc wheels—Hub-piloted
   1. Cone nut
   2. One-piece flanged cap nut
   3. Two-piece flanged cap nut
   4. Clamping plate

c. Disc wheels—Stud-piloted
   1. Serrated bolt
   2. Back or jam nut
   3. Stud

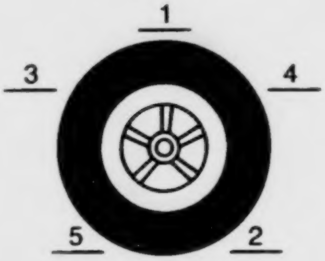
Objective 14

Any four of the following:

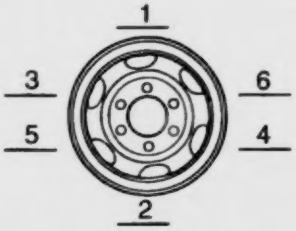
a. Cracked rim, wheel, or disc
b. Sprung or broken lock rings or side rings
c. Tubeless rim leaks
d. Corroded parts
e. Damaged inner or outer wheel cap nuts
f. Out-of-round wheel or rim (distortion)
g. Out-of-round or elongated stud holes on wheel
h. Cracked or bent valve cores
i. Damaged or worn clamps, rim spacer, rim studs, or spoke-wheel nuts

Objective 15

a. Spoke wheels



b. Disc wheels



Answers to Written Test

Objective 16

a. Lateral
b. Radial
c. Gauge
d. Sidewall
e. Tread
f. Before
g. Discomfort
h. Dynamically
i. Adding
j. The same

Objective 17

a. Never
b. Always
c. Always
d. Always
e. Do not
f. Never
g. Always
h. Always
i. Never
j. Always
k. Never
l. Always
m. Never

Objective 18

a. Inflation
b. Inflation
c. Underinflation
d. Overinflation
e. Pressure
f. Low
g. 1/8"
h. Petroleum

Prerequisites:
None

Learning Activities Sheet

Student Name ____________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 9.

Optional

☐ 4. **View** Videotape entitled "Tire Wear Diagnosis."

☐ 5. **Do** Job Sheet 1, "Diagnose Unusual Tire Wear Patterns, Check Tire Pressure, and Measure and Match Tires."

☐ 6. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 7. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Step 5.

☐ 7. **Study** Information Sheet, Objectives 10 through 18.

Optional

☐ 8. **View** Videotapes entitled "Wheel and Rim Inspection," "Wheel/Rim Inspection and Cleaning," and "WHD-8 Installation and Maintenance."

☐ 9. **Do** Job Sheet 2, "Diagnose Tire/Wheel Vibration, Inspect Mounting Hardware, and Check Tire/Wheel Roundout and Balance."

☐ 10. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 11. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 9.

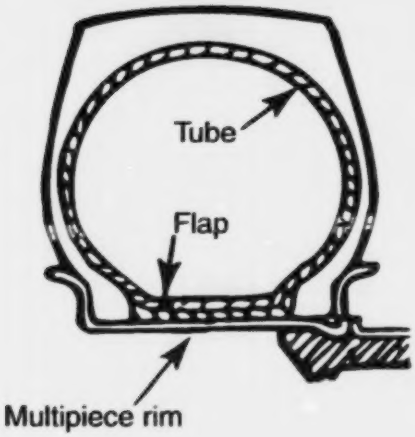
☐ 11. **Check** With instructor for any additional assignments to be completed.

☐ 12. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

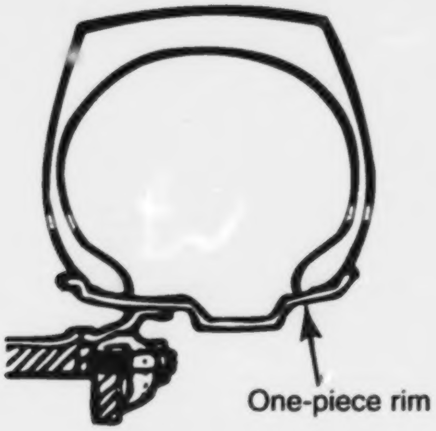
☐ 13. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

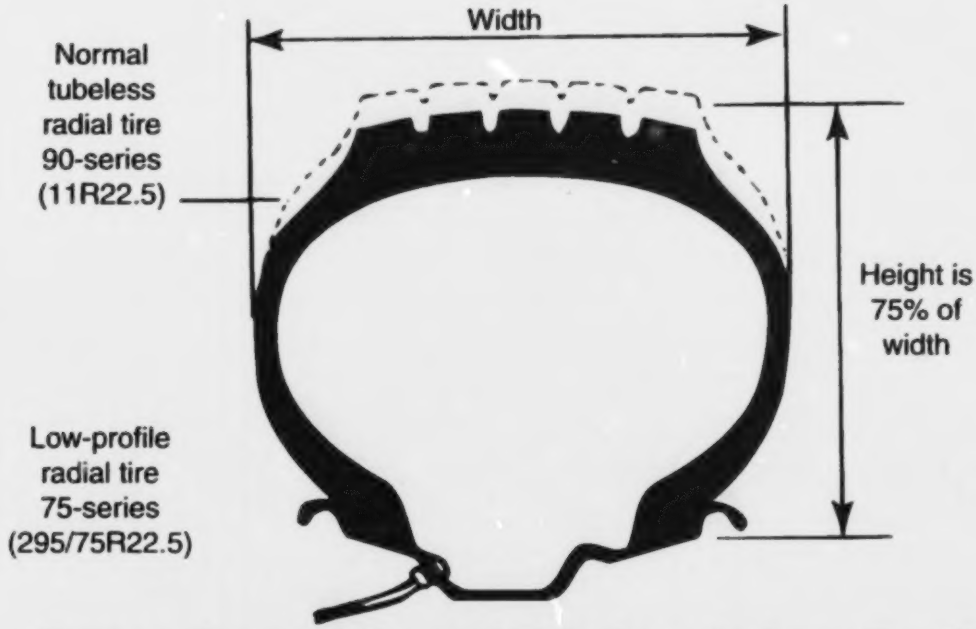
Types of Tires


Tube
Flap
Multipiece rim

Tube-Type Tire


One-piece rim

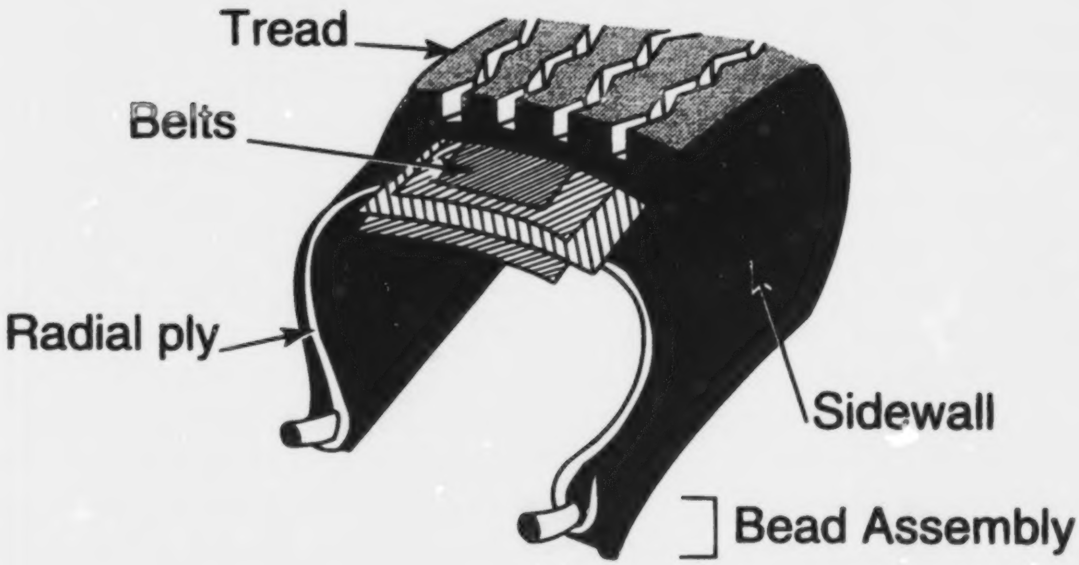
Tubeless Tire


Width
Normal tubeless radial tire 90-series (11R22.5)
Height is 75% of width
Low-profile radial tire 75-series (295/75R22.5)

Comparison of Normal Tubeless to Low-Profile

Courtesy of The Maintenance Council (TMC) of the American Trucking Associations. 800-ATA-LINE. reprinted with permission.

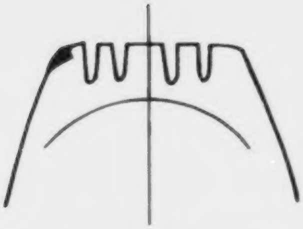
Parts of a Radial Tubeless Tire


Tread
Belts
Radial ply
Sidewall
Bead Assembly

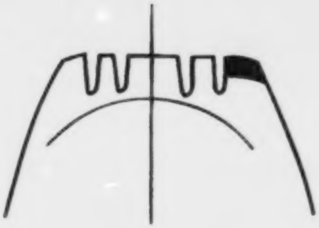
Courtesy of The Maintenance Council (TMC) of the American Trucking Associations. 800-ATA-LINE. reprinted with permission.

TM 2

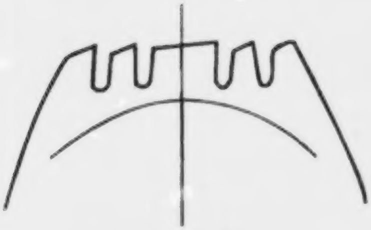
Radial Wear Conditions



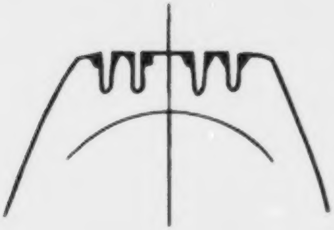
Shoulder Step/Chamfer Wear



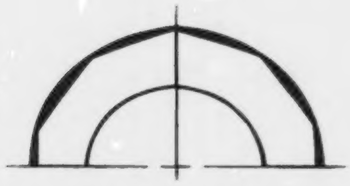
Full Shoulder Wear, usually one side only



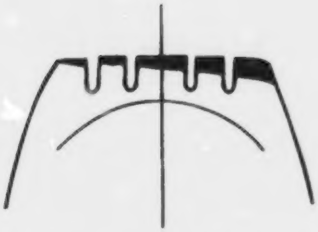
Feather Wear



Erosion/River/Channel Wear



Cupping/Scallop Wear

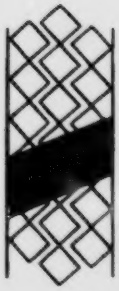


One-sided Wear

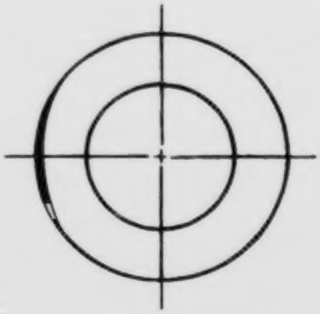
Courtesy of Maintenance Council

Radial Wear Conditions

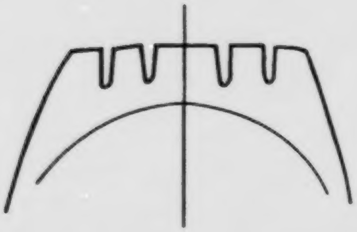
(continued)



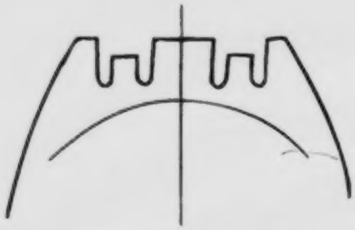
Diagonal Wear



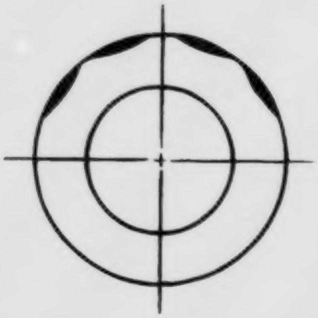
Eccentric/Out-of-Round Wear



Overall Fast Wear



Rib Depression/Punch Wear

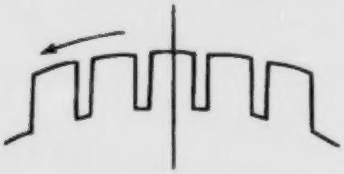


Erratic Depression Wear

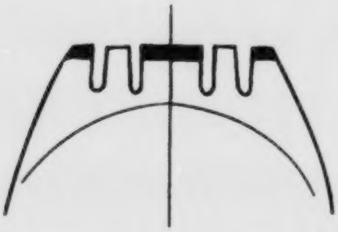
Courtesy of Maintenance Council

Radial Wear Conditions

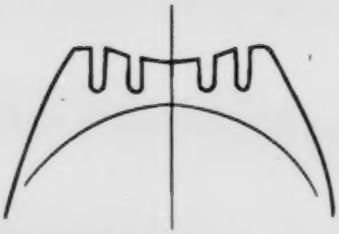
(continued)



Heal/Toe Wear



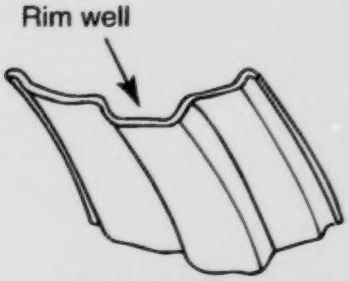
Alternate Lug Wear



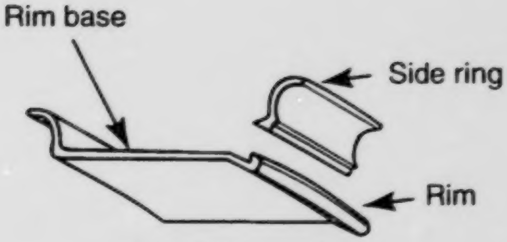
Brake Skid/Flat Spot Wear

Courtesy of Maintenance Council

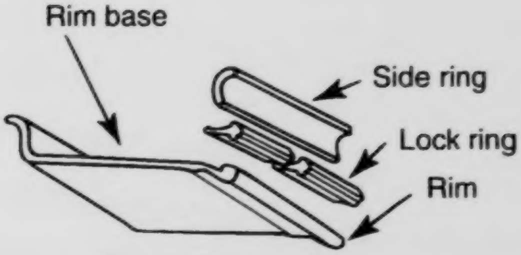
Types of Rims



Single-Piece Rim


Rim base
Side ring
Rim

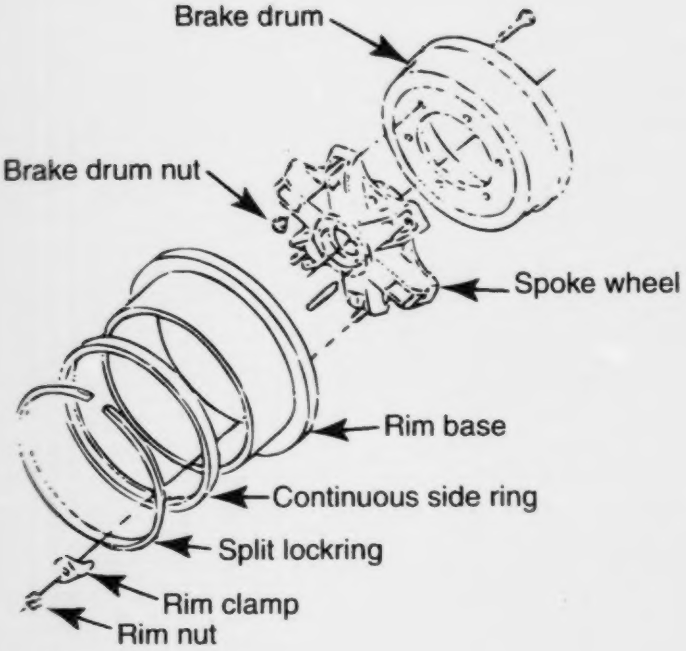
Two-Piece Rim


Rim base
Side ring
Lock ring
Rim

Three-Piece Rim

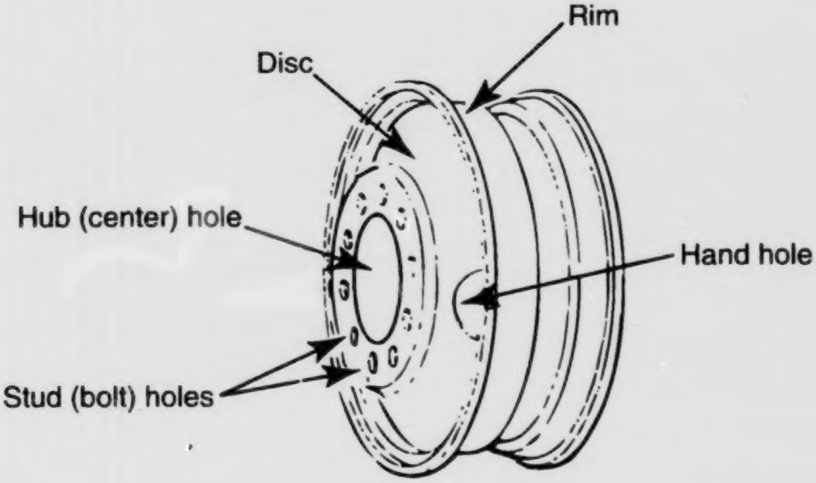
Courtesy of Goodyear

Parts of a Cast Spoke Wheel


Brake drum
Brake drum nut
Spoke wheel
Rim base
Continuous side ring
Split lockring
Rim clamp
Rim nut

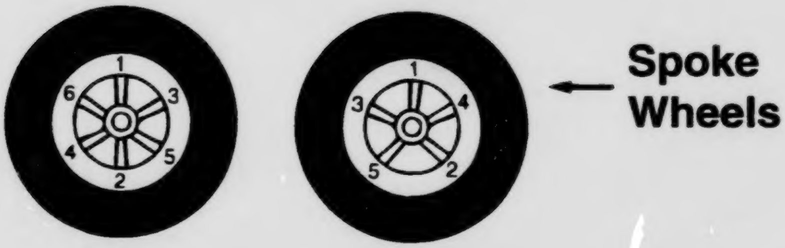
Courtesy of Freightliner Corporation

Parts of a Disc Wheel

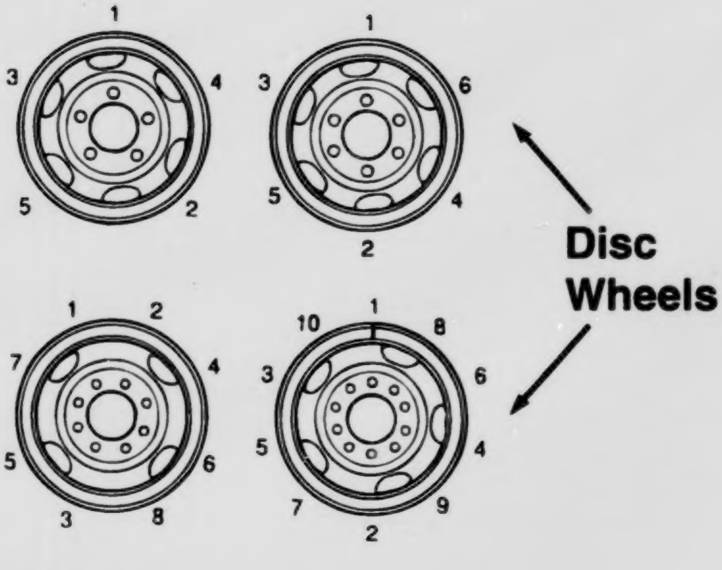

Rim
Disc
Hub (center) hole
Hand hole
Stud (bolt) holes

Courtesy of Freightliner Corporation

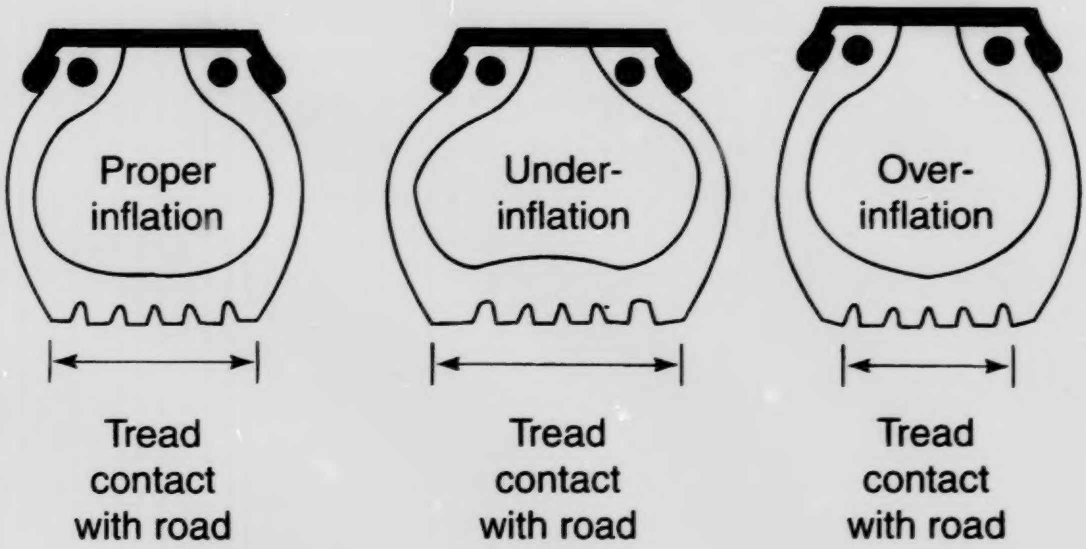
Wheel Tightening Sequences


1
6
3
4
5
2
1
3
4
5
2
Spoke Wheels

6-lug 5-lug


1
3
4
5
2
1
3
6
5
4
2
Disc Wheels
1
2
7
4
5
6
3
8
10
1
8
3
6
5
4
7
9
2

Tire Inflation


Proper inflation
Under-inflation
Over-inflation
Tread contact with road
Tread contact with road
Tread contact with road

Courtesy of Peterbilt Motors Company/PACCAR Inc.

Unit 3-A Chassis Components

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2—Frame Reinforcements 3A-25
3—Types of Fifth Wheel Mounting Plates 3A-27
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Student Page

Student Components

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3—Inspect and Service Fifth Wheel Assemblies, Pintle Hitch, Kingpin, and Trailer Plate 3A-31
4—Couple and Uncouple Fifth Wheel 3A-35

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Take students on a walkaround of a diesel-powered vehicle to show the basic chassis components. Discuss the functions of the different parts and how they work together.
- Show examples of frames that have been reinforced with fish plating, gussets, and/or brackets.
- Discuss the common procedures performed on frames. Point out the ones that are the most common and those that are the most time-consuming.
- Discuss the special guidelines that must be followed when working on frames, such as those for drilling and welding.
- Show examples of the basic fasteners used on frames. Show standard cold rivets and huck rivets, as well as the special SAE and metric body-bound bolts. Discuss when they might be used. Also demonstrate how they are used.
- Show examples of frame damage, and have students identify what caused the various types of damage.
- Demonstrate the correct techniques to use when repairing frames. Show the correct tools and equipment to be used. Make sure students have demonstrated skill competency and completed their safety training before using shop equipment.
- Demonstrate the correct procedure to use for checking frame alignment. Discuss what can be done for frames that are slightly bent or severely bent.
- Show examples of the basic types of fifth wheels. Have students identify the main components. Also have them point out the different types of mounting plates and locking mechanisms.
- Have students identify the various parts of a trailer available in the shop.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.

- Reteach and retest as required.

Suggested Activities

Resources Used in Developing This Unit

Print Media

- Byrnes, Mike and Associates. *Bumper to Bumper.* Phoenix, AZ: Barron's Educational Series, Inc., 1993.
- *Fifth Wheel Selection Guide* (FW226). Holland, MI: Holland Hitch Company, 1991.
- *Frame Manual* (14.200). Allentown, PA: Mack Trucks Inc., 1986.
- *Freightliner COE & 120 Conventional Service Manual (Section 13.00).* Portland, OR: Freightliner Corporation, 1989.
- *Freightliner FLA COE & FLD Conventional Service Manual (Section 22.09).* Portland, OR: Freightliner Corporation, 1990.
- *Mounting Fifth Wheels* (Accessories 18.1) from *Mack Master Manual.* Allentown, PA: Mack Trucks Inc., 1980.
- *1994-95 Recommended Maintenance Practices Manual.* Alexandria, VA: The Maintenance Council.
- Norman, Ian Andrew, Robert Scharff, and John A. Corinchock. *Heavy Duty Truck Systems,* 2nd edition. Albany, NY: Delmar Publishers, 1996.
- Schultz, Erich J. *Diesel Equipment I and II.* New York: McGraw-Hill Book Company, 1982.

Suggested Supplemental Resources

Print Media

- Specification catalogs, operating and maintenance manuals, and videos about Simplex series and other fifth wheels are available from:

  American Steel Foundries
  3761 Canal Street
  East Chicago, IN 46512
  1-312-968-9100

- *Frame, Axle, and Wheel Alignment* service manual (#4-301)
- *Frame, Springs, and Suspension* service manual (#14-100)

  The above are available from your local Mack Truck service center or contact:

  Mack Trucks, Inc.
  2100 Mack Blvd.
  P.O. Box M
  Allentown, PA 18105-5000

- *Techniques of Structural Repair—Instructor Notes,* 192-page course (SEGV2551) and *Supplemental Material,* 28 pages (SEGV2550). Available from your local CAT dealer or write the following for more information:

  Caterpillar Service Training
  600 W. Washington St., Bldg. JJ
  East Peoria, IL 61630

Electronic Media

- *Hooking Up Doubles* videotape. (T0290) Covers method for safely coupling and uncoupling multiple trailer vehicles. Available from:

  American Trucking Associations
  Customer Services Dept.
  2200 Mill Road
  Alexandria, VA 22314-4677
  1-800-ATA-LINE

- *King Bolt Installation,* 15-minute videotape. (VH1-26PT). Discusses removal/replacement of king pins, including metal bushing reamed for alignment. Available from:

  Dana Corporation
  Publication Services
  P.O. Box 453
  Toledo, OH 43692-0453
  419-535-4285

- *How to Get the Most From Your Holland FW3500/FW3600 Series Fifth Wheel,* 20-minute videotape.
- *Coupling and Uncoupling Procedures for Tractors/Trailers* videotape
- *Installation Procedures* videotape

  The above are available from:

  Holland Hitch Co.
  467 Ottawa Avenue
  Holland, MI 49423
  1-616-396-6501

- *WhiteGMC Fifth Wheel Operation and Maintenance,* 12-minute videotape. Available from:

  Volvo GM Heavy Truck Corp.
  P.O. Box 26115
  Greensboro, NC 27402
  1-910-393-2430

Written Test

Name ______________________________

Date ______________________ Score__________

Objective 1

Match the terms with their definitions.

1. Body-bound bolt
2. Channel
3. Chassis
4. Couple/uncouple
5. Fifth wheel
6. Flange
7. Frame stations
8. Huck rivet
9. Kingpin
10. Pintle gear
11. Running gear
12. Web
13. Yield strength

_____ a. Coupling mechanism that joins two trailers together

_____ b. Supporting frame of a vehicle; everything below the cab

_____ c. Plate connecting upper and lower flanges on a frame rail

_____ d. Point on the trailer that connects to the tractor's fifth wheel

_____ e. Type of fastener in which nut is crimped to cap screw; cannot be removed with conventional tools

_____ f. Type of bolt with a special shoulder that fits tightly in the drilled/reamed bolt hole to prevent movement of mating parts

_____ g. Projecting rib or rim of an object (such as a frame rail) used for strength and for attachment to another object

_____ h. Inside C-shaped area on a frame rail

_____ i. Combined parts of a trailer that allow it to be pulled down the road

_____ j. Coupling mechanism on the tractor that joins the tractor to the trailer

Written Test

Objective 2

Select the basic chassis components from the following list by placing an "X" in the blanks next to the true statements.

_____ a. Fifth wheel

_____ b. Engine

_____ c. Frame assembly

_____ d. Axles

_____ e. Brakes

_____ f. Suspension components

_____ g. Trailer

Objective 3

Complete statements concerning the parts of a frame assembly by filling in the blanks with the correct answers.

a. A typical frame has ________________ rails.

b. Each rail consists of an upper flange, a lower flange, and a ________________.

c. There are usually four to six ________________. ________________ located between the rails.

d. The primary purposes of cross members are to stabilize and secure the ________________ to support vehicle components such as radiator, engine, and cab.

e. Cross members also serve as ________________. ________________.for accessories such as air tanks and fuel tanks.

Objective 4

Select true statements concerning frame construction by placing a "T" or "F" next to the true or false statements.

_____ a. There are ten basic design styles of frames.

_____ b. A dropped frame has straight, parallel rails.

_____ c. Frame rails may be made of aluminum, carbon steel, or steel alloy.

_____ d. The yield strength of aluminum is higher than steel alloy.

Written Test

Objective 5

Complete statements concerning frame reinforcements by circling the correct answers.

a. Frame rail reinforcements are used to (**increase, decrease**) the resistance to bending and twisting forces and to (**increase, decrease**) the load-carrying capacity.

b. Fish plating consists of bolting a steel plate to the (**outside rails, cross members**). It is applied to a standard frame when a vehicle must carry a load greater than the design allows, or when the vehicle has to operate on rough terrain.

c. Gussets and brackets are steel plates or angle iron reinforcements (**welded, bolted**) to the rails for additional strength.

Objective 6

List three common procedures performed on frames.

a. ______________________________

b. ______________________________

c. ______________________________

Objective 7

Complete statements concerning guidelines for working on frames by circling the correct answers.

a. When lifting or moving frame rails, use special care so you do not (**cut, torch**) the exposed frame assembly.

b. (**Never, Always**) heat the frame rails for straightening purposes.

c. Avoid (**drilling, bolting**) when possible. Use existing holes placed by the factory.

d. Do not drill holes beyond the central (⅓, ½) of the web area.

e. Do not drill any holes (**smaller, larger**) than the existing cross member or spring bracket bolt holes made by the manufacturer.

f. Do not drill more than (**two, four**) holes on a vertical line.

g. (**Sand, Clean**) both surfaces before bolting together.

h. Whenever (**like, unlike**) metals are fastened together, special steps must be taken to prevent corrosion.

i. Disconnect the (**ground cable, discharge plug**) from the truck's battery before welding or cutting to prevent damage to electrical and electronic components.

j. (**Do, Do not**) weld attachments directly to the frame rail.

Written Test

Objective 8

List two things to check on frames.

a. ______________________________

b. ______________________________

Objective 9

Select true statements concerning frame fasteners by placing a "T" or "F" in the blanks next to the true or false statements.

_____ a. Components may be fastened to the frame using rivets or bolts

_____ b. The goal of both methods of fastening is "to allow for movement between mating parts."

_____ c. Special SAE or metric body-bound bolts are used to prevent parts from bearing on the threaded portion of the bolt.

_____ d. A rubber washer must be used under each nut.

Objective 10

List three causes of stress leading to frame damage.

a. ______________________________

b. ______________________________

c. ______________________________

Objective 11

Distinguish between correct and incorrect practices to follow in frame repairs by placing a "C" next to correct practices and an "I" next to incorrect practices.

_____ a. Use short reinforcement plates that do not extend beyond the critical area.

_____ b. Avoid section gaps caused by the reinforcement plates stopping short of ends of adjacent cross member gussets or brackets.

_____ c. Avoid several holes in direct vertical alignment or holes too close together.

_____ d. Weld all large cracks.

_____ e. Repair enlarged holes by reaming to accept the next larger bolt diameter.

Objective 12

Complete statements concerning the basic procedure for checking alignment by circling the correct answers.

a. Check alignment by transferring vehicle reference points to a level floor with a (**spirit level, plumb bob**).

b. Locate reference points at (**different, the same**) positions on both sides of the vehicle.

c. Hang a plumb bob string through the trunnion and wheel hub centerlines and over the front of the (**nut, washer**) at specified frame rail bolt locations.

d. Use (**paint, masking tape**) under the plumb bob and accurately mark the location with a pencil.

e. (**Do, Do not**) move the vehicle after marking the points on the floor.

f. Snap a chalk line to connect the points in a (**parallel, crisscross**) pattern.

g. Measure lines and compare measurements to check frame for (**parallelism, squareness**).

Objective 13

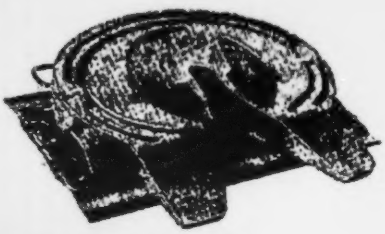
State one purpose of a fifth wheel.

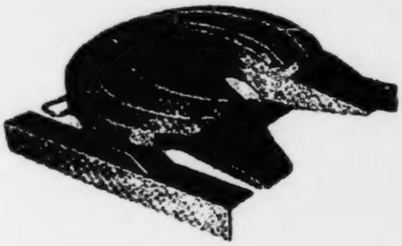
____

____

Objective 14

Identify the following types of fifth wheel mounting plate.. Write your answers in the blanks provided.





Courtesy of Holland Hitch Co.

a. ______________________ b. ______________________

Objective 15

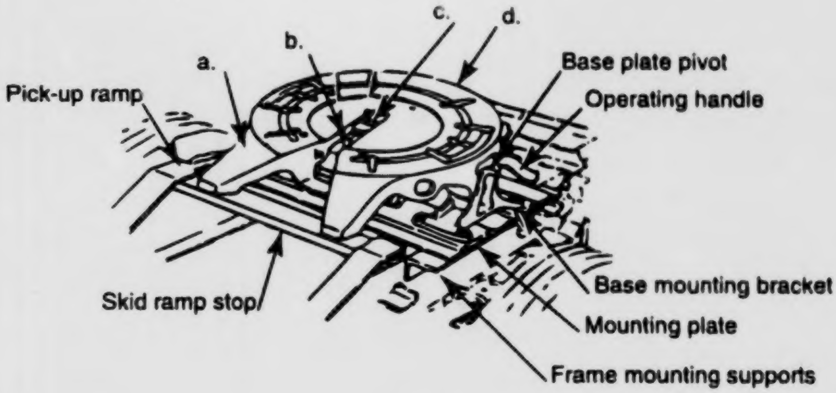
Name one basic type of fifth wheel locking mechanism.

____

Written Test

Objective 16

Identify the main components of a typical fifth wheel. Write your answers in the blanks provided.


c.
d.
b.
a.
Base plate pivot
Pick-up ramp
Operating handle
Base mounting bracket
Skid ramp stop
Mounting plate
Frame mounting supports

a. ______________________ c. ______________________

b. ______________________ d. ______________________

Objective 17

Match the parts of a trailer with their functions. Definitions continue on the next page.

1. Air system
2. Axles
3. Brakes
4. Bulkhead
5. Doors
6. Floor, walls, ceiling, and roof
7. Inside or outside rails
8. Kingpin
9. Landing gear
10. Lights and electrical wiring
11. Sliding tandems
12. Suspension system
13. Tires
14. Wheels

_____ a. Transmit the weight of the cargo from the axles to the tires; provide rotary motion

_____ b. Used to provide a smooth ride for driver and cargo

_____ c. Parts of the van's box shell that protect the cargo; commonly made of aluminum and reinforced, lightweight material such as fiberglass reinforced plastic (FRP)

_____ d. Carry the weight of the cargo and transmit the load to the wheels

_____ e. Used to adjust the wheelbase of the trailer to help distribute trailer weight

_____ f. Consists of two air couplings ("glad hands") that transmit air pressure from the tractor to the trailer brakes

_____ g. Wall on the front of a trailer that prevents cargo from sliding into tractor during stops

_____ h. Allow access to the cargo; commonly swinging type or roll-up type

_____ i. Holds up the front of the railer when the trailer isn't hooked to the trailer.

_____ j. Slow and stop movement; consist of service and emergency types

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 10
b. 3
c. 12
d. 9
e 8
f. 1
g. 6
h. 2
i. 11
j. 5

Objective 2

a, c, d, f

Objective 3

a. Two
b. Web or channel
c. Cross members
d. Rails
e. Mounting pads

Objective 4

a. F
b. F
c. T
d. F

Objective 5

a. Increase, increase
b. Outside rails
c. Bolted

Objective 6

Any three of the following:

a. Adding attachments such as fuel tank brankets, air tank, etc.
b. Lengthening frame
c. Reinforcement (strengthening) frame
d. Repairing cracks in rails and/or cross members
e. Removing/replacing/adding cross members
f. Straightening frame
g. Checking frame alignment

Objective 7

a. Cut
b. Never
c. Drilling
d. $^1/_3$
e. Larger
f. Two
g. Clean
h. Unlike
i. Ground cable
j. Do not

Answers to Written Test

Objective 8

Any two of the following:

a. Loose or missing bolts or rivets
b. Cracks in side rails, cross members, and brackets
c. Elongated holes in side rails, cross members, and brackets
d. Distortion and lack of alignment

Objective 9

a. T
b. F
c. T
d. F

Objective 10

Any three of the following:

a. Incorrect bolting patterns
b. Notches
c. Improper load concentrations, including overloading and uneven loading
d. Loose bolts
e. Abrupt change in section
f. Operating vehicle on extremely rough terrain
g. Rail flanges that have been welded or drilled with holes

Objective 11

a. I
b. C
c. C
d. I
e. C

Objective 12

a. Plumb bob
b. The same
c. Washer
d. Masking tape
e. Do
f. Crisscross
g. Mounting pads

Objective 13

Either of the following:

a. To connect the tractor (power unit) to the trailer (payload/cargo)
b. To allow pivoting between the tractor and the trailer for turning corners or reversing

Objective 14

a. Sliding mounting plate
b. Stationary mounting plate

Objective 15

Either of the following:

a. Holland®
b. Simplex®

Objective 16

a. Skid ramp
b. Throat
c. Coupler jaws
d. Skid plate

Objective 17

a.	14	f.	1
b.	12	g.	4
c.	6	h.	5
d.	2	i.	9
e	11	j.	3

Prerequisites:
None

Learning Activities Sheet

Student Name ____________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 11.

☐ 4. **Do** Job Sheet 1, "Inspect and Install or Repair Frame, Hangers, Brackets, and Cross Members."

☐ 5. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 6. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Step 4.

☐ 6. **Study** Information Sheet, Objective 12.

☐ 7. **Do** Job Sheet 2, "Check and Inspect Vehicle Frame Alignment."

☐ 8. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 9. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 7.

☐ 9. **Study** Information Sheet, Objectives 13 through 16.

Optional

☐ 10. **View** Videotape entitled "King Bolt Installation."

☐ 11. **Do** Job Sheet 3, "Inspect and Service Fifth Wheel Assemblies, Pintle Hitch, Kingpin, and Trailer Plate."

☐ 12. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 13. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Step 11.

☐ 13. **Study** Information Sheet, Objective 17.

Optional

☐ 14. **View** Videotapes entitled "Hooking Up Doubles," "Coupling and Uncoupling Procedures for Tractor/Trailers," and "Installation Procedures."

☐ 15. **Do** Job Sheet 4, "Couple and Uncouple Fifth Wheel."

☐ 16. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 17. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 4 and repeat Step 15.

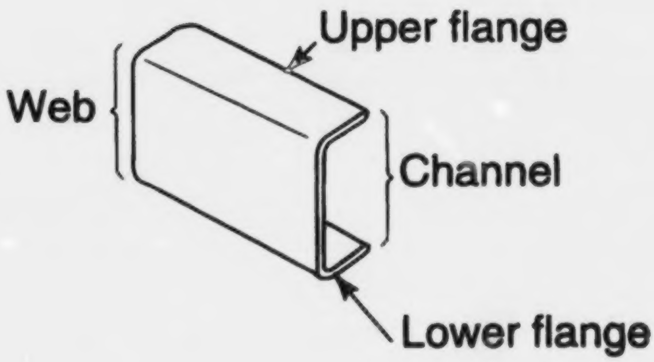
☐ 17. **Check** With instructor for any additional assignments to be completed.

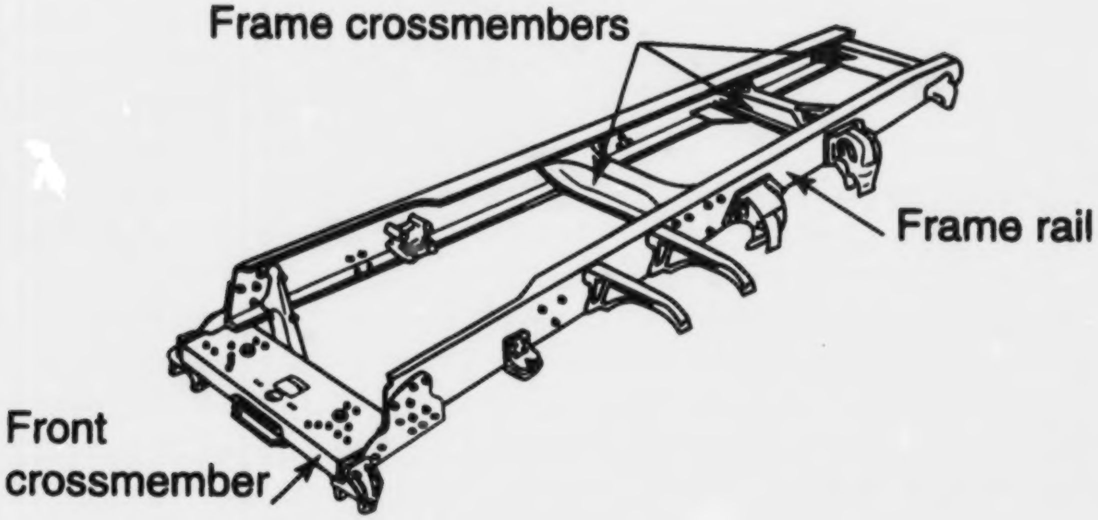
☐ 18. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 19. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

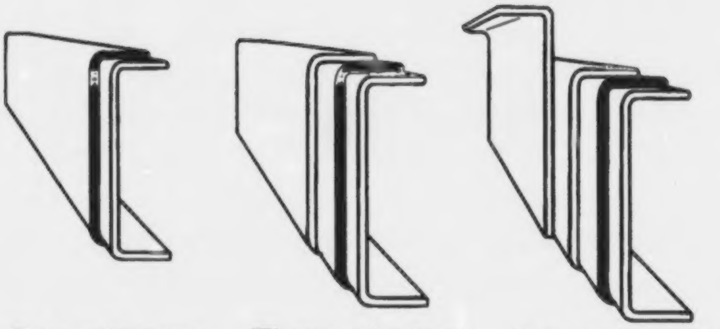
Parts of a Rail Assembly


Upper flange
Web
Channel
Lower flange

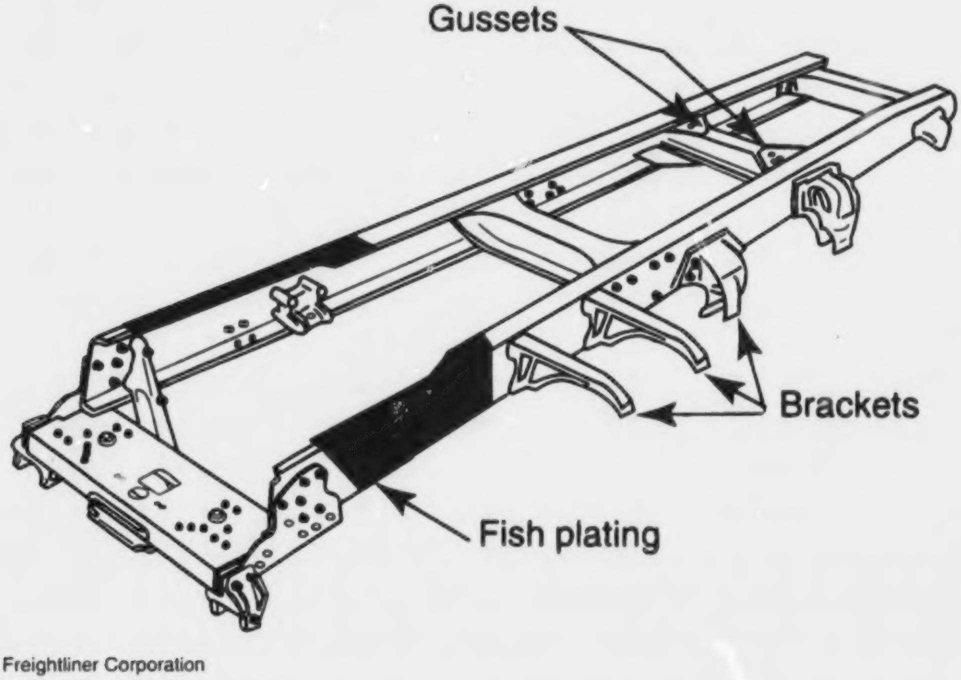

Frame crossmembers
Frame rail
Front
crossmember

Courtesy of Freightliner Corporation

Frame Reinforcements

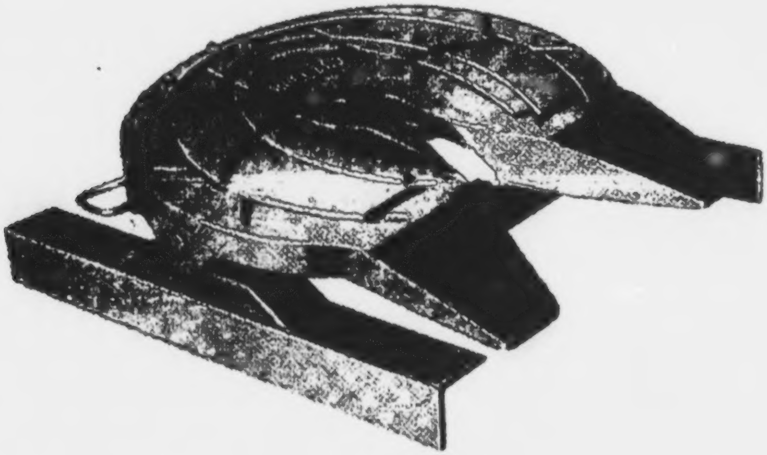


Two-element Three-element Four-element

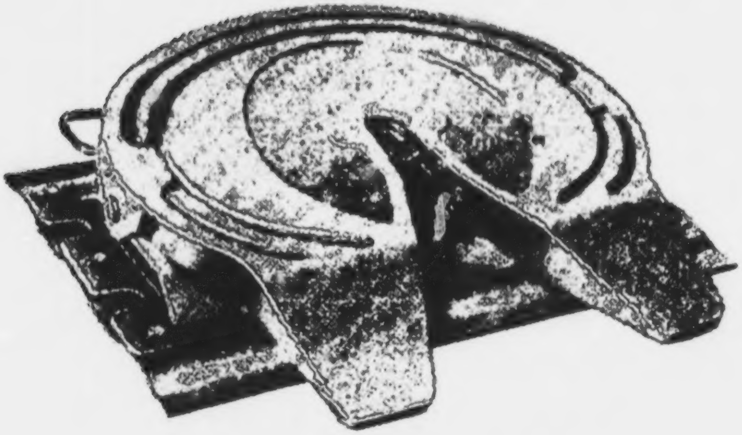

Gussets
Brackets
Fish plating

Courtesy of Freightliner Corporation

Types of Fifth Wheel Mounting Plates



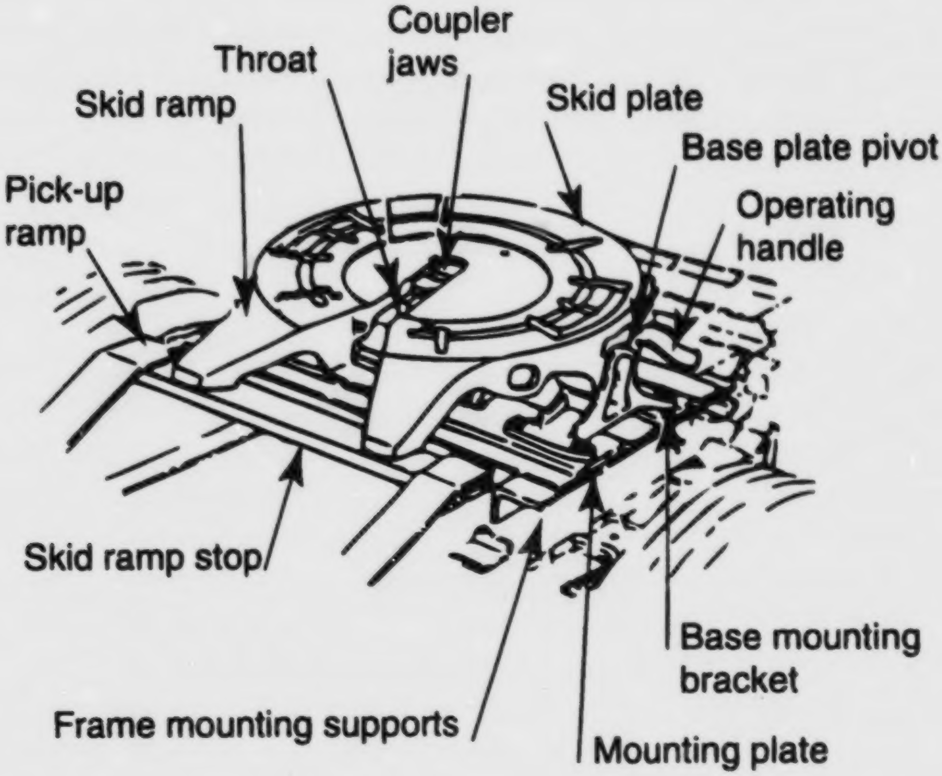
Stationary Mounting Plate



Sliding Mounting Plate

Courtesy of Holland Hitch Co.

Main Components of a Typical Fifth Wheel


Coupler jaws
Throat
Skid ramp
Skid plate
Base plate pivot
Pick-up ramp
Operating handle
Skid ramp stop
Base mounting bracket
Frame mounting supports
Mounting plate

Courtesy of Mack

Unit 1-B

Steering Column and Manual Steering Gear

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 1B–3

Written Test 1B–9

Answers to Written Test 1B–15

Learning Activities Sheet 1B–17

Transparency Masters

1—Parts of a Standard Steering Column and Manual Steering Gear Assembly 1B–19
2—Parts of a Tilt/Telescoping Steering Column Assembly 1B–21
3—Parts of a Recirculating Ball Manual Steering Gear 1B–23
4—Parts of a Cam and Lever Manual Steering Gear 1B–25
5—Parts of a Worm and Roller Steering Gear 1B–27

Student Components

Student Page

Objective Sheet 1B–3

Information Sheet 1B–5

Job Sheets

1—Diagnose and Troubleshoot Problems on the Steering Column and Steering Gear Assembly 1B–15
2—Remove Steering Wheel, Inspect, Repair, or Replace to Proper Alignment Position 1B–19
3—Remove, Disassemble,and Remount the Steering Gear Assembly 1B–23
4—Perform Steering Gear Adjustments 1B–27
5—Inspect and Replace Pitman Arm on Steering Gear Assembly . 1B–31
6—Inspect and Replace Steering U-Joints 1B–35

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Have students identify the different types of steering columns using vehicles available in the shop. Make sure they identify the main parts and features.

- Discuss the different types of manual steering gears, and point out the advantages and disadvantages of each type.

- Provide disassembled or cutaway manual steering gears so students can manipulate and understand their different parts and operation. Hands-on experience is very important, especially for tactile learners.

- Discuss the most common problems that you have encountered with manual steering gears. Describe what may be required to solve each problem.

- Show examples of the specialty tools and equipment used for work on steering systems. Demonstrate how to use or operate the tools and equipment. Review safety rules as necessary.

- Provide examples of manual steering gears in need of repair and manufacturers' troubleshooting guides or service manuals for students to use in Job Sheet 1. You may want to also provide gears with simple problems for students to practice on prior to Job Sheet 1.

- Make sure the appropriate tools, equipment, and service manuals are available for students to use in the job sheets.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *Navistar Service Manual, CTS-5167.* Chicago: Navistar International Transportation Corp., 1994.
- Norman, Ian Andrew, Robert Scharff, and John A. Corinchock. *Heavy Duty Truck Systems,* 2nd edition. Albany, NY: Delmar Publishers, 1996.
- *Peterbilt Maintenance Manual (for Models 379, 377, 375, 357, and 355) (Catalog #5290).* Newark, CA: Peterbilt Motors Company, 1987.
- *Truck Systems Design Handbook.* Warrendale, PA: Society of Automotive Engineers, Inc., 1992.

Suggested Activities

Suggested Supplemental Resources

Print Media

- *How to Service and Install Universal Joints Instruction Manual* (#457302). Available from:

  CR Services
  735 Tollgate Road
  Elgin, IL 60123
  800-882-0008 or 847-742-7840

- *Total Service Package.* Includes a complete set of service manuals and service bulletins for TRW steering gears and components, as well as the *Chart Your Way to Easy Steering Video Kit* and the *TAS Poppet Video Kit.*

  The above, as well as Ross service manuals, are available from:

  TRW/Ross Gear Division—Commercial Steering
  P.O. Box 60
  800 Heath Street
  Lafayette, IN 47902-0060
  1-317-429-1923

- *Front Axle and Steering System Service Manual* (12-101)

- *Ross Manual Steering Gears Service Manual* (500-8)

  The above are available from your local Mack Truck service center or contact:

  Mack Trucks, Inc.
  2100 Mack Blvd.
  P.O. Box M
  Allentown, PA 18105-5000
  1-610-439-3011

Electronic Media

- *Chart Your Way to Easy Steering Video Kit*—Includes two videotapes, troubleshooting guide, diagnostic flowcharts, and a grease pencil for diagnosing the ten most common driver complaints.

  The above, as well as Ross service manuals, are available from:

  TRW/Ross Gear Division—Commercial Steering
  P.O. Box 60
  800 Heath Street
  Lafayette, IN 47902-0060
  1-317-429-1923

- *U-Joint Failures,* 13-minute videotape (VH1-31PT). Discusses the most common cause of universal joint failure—lack of proper lubrication—and then explains the remedy.

The above is available from your local Mack Truck service center or contact:

Mack Trucks, Inc.
2100 Mack Blvd.
P.O. Box M
Allentown, PA 18105-5000
1-610-439-3011

- *994 Wheel Loader—Steering and Brake Systems* (SEGV2602), 55 slides (1995)
- *785B/789B/793B Off-Highway Trucks—Steering System,* 41 slides (SEGV2587), and textbook (SEBV2587), (1993)
- *769C/771C/773B/775B/777C Off-Highway Trucks—Steering System,* 18 slides (SEGV2586), and textbook (SEBV2586), (1993)
- *785 Off-Highway Truck—Steering System* (SESV1492), 30 slides (1985)

The above are available from your local CAT dealer or write the following for more information:

Caterpillar Service Training
600 W. Washington St., Bldg. JJ
East Peoria, IL 61630

Written Test

Name ____________________

Date ____________________ Score __________

Objective 1

Match terms associated with the steering column and manual steering gear with their definitions.

1. Bearing preload
2. Manual steering gear
3. Pitman arm
4. Shims
5. Slack
6. Steering column
7. Steering ratio
8. Steering shaft
9. Steering u-joint
10. Steering wheel
11. Stud
12. Telescoping
13. Tilting

_____ a. Wheel assembly mounted on top of the steering column that transfers driver input turning torque effort to the steering gear which in turn controls direction of the vehicle

_____ b. Mechanical device used to convert the rotary motion at the steering wheel to a lateral motion at the steering axle

_____ c. Numerical ratio representing the number of turns made by the steering wheel to steering lever shaft

_____ d. Adjusting height by means of sliding inner and outer tubes

_____ e. Thin pieces of metal in various thicknesses that may be used to preload bearings

_____ f. Part connecting the steering gear shaft and steering linkage

_____ g. Component fastened to cab instrument panel that houses the steering shaft with bearing supports and that provides connection between steering wheel and steering gear assembly

_____ h. Hinge-like fastener (ball- or tapered cone-shape) where adjustments can be made to reduce slack

_____ i. Amount of pressure put on a bearing to reduce slack in the bearing

_____ j. Tube or rod that connects the steering wheel (cab mounted) to the steering gear (chassis mounted)

_____ k. Adjusting angle by rotation forward (up) or rearward (down)

Objective 2

State two purposes of a steering column and steering gear assembly.

a. ____________________

b. ____________________

Written Test

Objective 3

Describe the basic types of steering columns.

a. ____

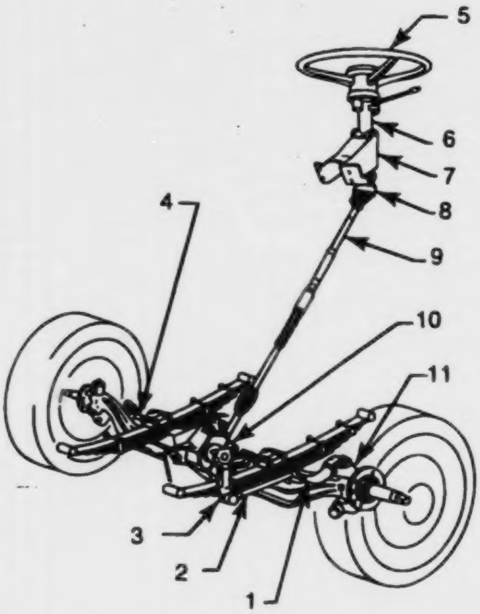
____

b. ____

____

Objective 4

Match the parts of a standard steering column and manual steering gear assembly with the correct illustrations.



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_____ a. Drag link

_____ b. Pitman arm

_____ c. Spindle & king assembly

_____ d. Steering arm

_____ e. Steering column

_____ f. Steering column support bracket

_____ g. Steering gear

_____ h. Steering shaft

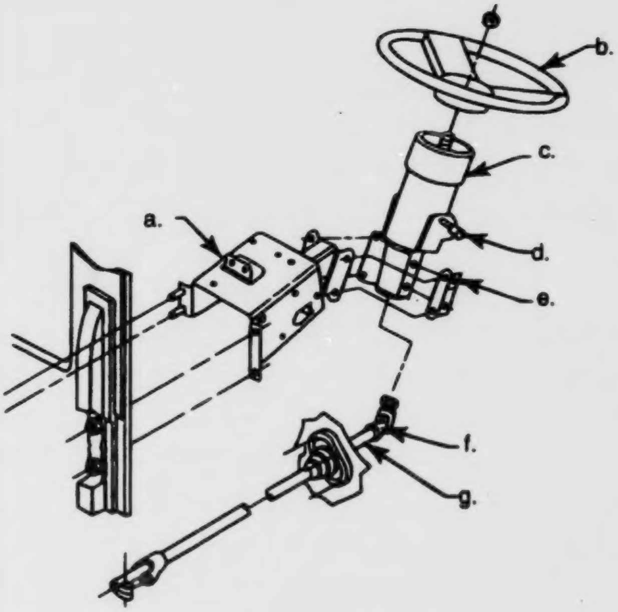
_____ i. Steering wheel

_____ j. Tie rod

_____ k. U-joint

Objective 5

Identify the parts of a tilt/telescoping steering column assembly. Write your answers in the blanks provided.



Courtesy of Navistar International Transportation Corp.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e ____________________

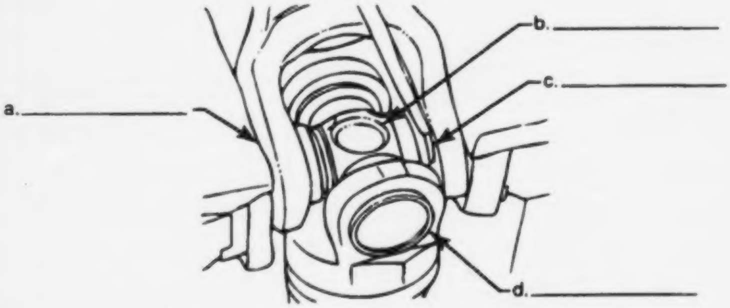
f. ____________________

g. ____________________

Written Test

Objective 6

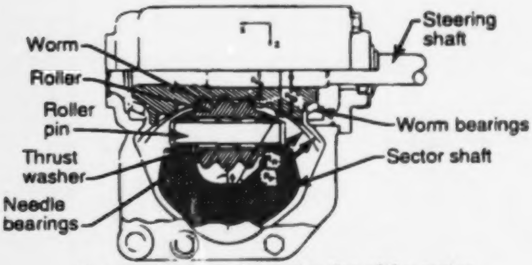
Label the parts of a universal joint.



Courtesy of Navistar International Transportation Corp.

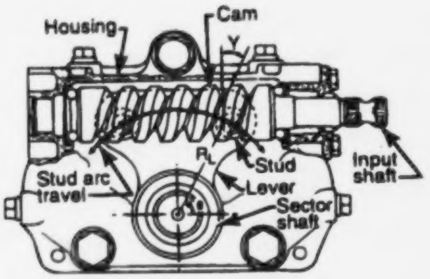
Objective 7

Identify the following types of manual steering gears. Write your answers in the blanks provided.


Worm
Roller
Roller pin
Thrust washer
Needle bearings
Steering shaft
Worm bearings
Sector shaft

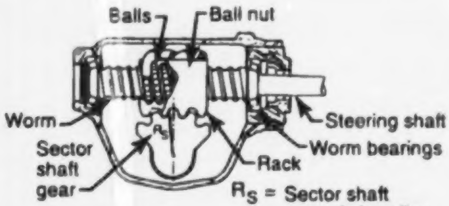
R_R = Radius from the center line of the sector shaft to the contact point of the worm

R_P = Radius of the worm pitch line


Housing
Cam
Input shaft
Stud
R_L
Lever
Stud arc travel
Sector shaft

Courtesy of TRW Commercial Steering Division

a. ____________________ b. ____________________


Balls
Ball nut
Worm
Steering shaft
Worm bearings
Sector shaft gear
Rack
R_S

R_S = Sector shaft gear pitch radius

Courtesy of TRW Commercial Steering Division

c. ____________________

Objective 8

Distinguish among the operation of manual steering gears by placing the following letter next to the correct descriptions:
R = next to recirculating ball
C = next to cam and lever
W = next to worm and roller

_____ a. Uses a constant diameter worm (called a cam in this case) on the input shaft and a cone shaped stud on the lever. As the cam turns, the stud follows and converts the arched motion of the contact point into sector shaft rotation.

_____ b. The input shaft portion has a semicircular grooved helix which provides one half of the path of travel for the recirculating balls. The other half of the path for the balls is a mating semicircular grooved helix cut on the inside of the nut. As the input shaft rotates, the helix causes the balls to circulate and to force the nut up or down the input shaft. The lower surface of the nut is cut with gear teeth on a rack which mesh with the gear teeth on the sector shaft. This converts the linear motion of the nut into rotational motion of the sector shaft.

_____ c Features an hourglass worm gear on the input shaft with a rotating toothed follower on the sector shaft. As the input worm turns, the roller follows and converts the curvilinear motion on the worm axis into sector shaft rotation.

Objective 9

List four common problems or complaints on manual steering gears.

a. ____

b. ____

c. ____

d. ____

Objective 10

Match common adjustments made on manual steering gears with their main purposes

1. Ball stud adjustment
2. Preload bearings on worm gear in steering gear
3. Side cover adjustment
4. Travel-stop adjustment

_____ a. To reduce travel (slack) on steering gear

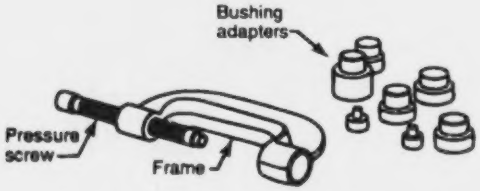
_____ b. To reduce slack (looseness) on pitman arm or steering arm

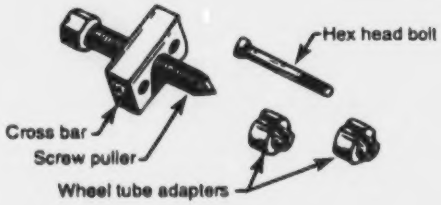
_____ c. To limit travel of wheels to prevent wheels from rubbing frame

_____ d. To reduce end travel; made with shims or adjusting plugs or screws

Written Test

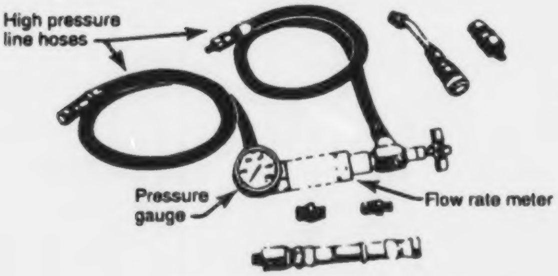
Objective 11 Identify the following specialty tools used for work on steering systems. Write your answers in the blanks provided.

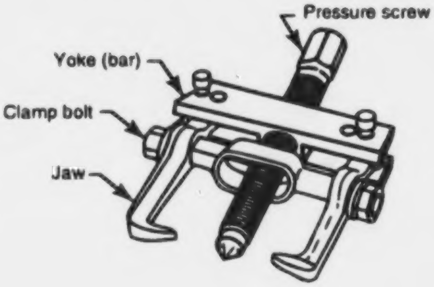

Bushing adapters
Pressure screw
Frame


Hex head bolt
Cross bar
Screw puller
Wheel tube adapters

Courtesy of Kent-Moore/SPX Corporation

a. ______________________ b. ______________________


High pressure line hoses
Pressure gauge
Flow rate meter


Pressure screw
Yoke (bar)
Clamp bolt
Jaw

Courtesy of Kent-Moore/SPX Corporation

c. ______________________ d. ______________________

Objective 12 Name one common lubricant used on steering gear assemblies.

____

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 10
b. 2
c. 7
d. 12
e. 4
f. 3
g. 6
h. 11
i. 1
j. 8
k. 13

Objective 2

Any two of the following:

a. To allow the operator to position the wheels which control the direction of travel
b. To allow the turning of the front wheels with a reasonable effort
c. To transmit the feel of the road to the operator

Objective 3

Descriptions should include the following in any order:

a. Fixed (standard)—Steering wheel cannot be moved; steering wheel is permanently placed in a position that suits the average driver's size and range of seat positions
b. Adjustable (tilt/telescoping)—Steering wheel can be moved in height and/or angle to provide optimum wheel-to-driver relationship in all seat positions

Objective 4

a. 2
b. 3
c. 11
d. 1
e. 6
f. 7
g. 10
h. 9
i. 5
j. 4
k. 8

Objective 5

a. Steering column support bracket assembly
b. Steering wheel
c. Steering column assembly housing
d. Tilt/telescoping lever
e. Steering column brackets
f. U-joint
g. Steering shaft

Objective 6

a. Yoke
b. Spider
c. Snap ring
d. Bearing

Answers to Written Test

Objective 7

a. Worm and roller
b. Cam and lever
c. Recirculating ball

Objective 8

a. C
b. R
c. W

Objective 9

Any four of the following:

a. Excess slack (looseness)
  - Caused by worn steering gear
  - Caused by worn U-joints
b. Hard turning or steering
c. Binding
d. Locking
e. Pulling to one side
f. Noisy steering

Objective 10

a. 3
b. 1
c. 4
d. 2

Objective 11

a. Universal joint tool
b. Steering wheel puller
c. Power steering analyzer
d. Pitman arm puller

Objective 12

Any two of the following:

a. SAE 80W-90 gear lubricant API GL-5
b. SAE 50W HD mineral oil

Unit 1–B

Steering Column and Manual Steering Gear

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 3.

☐ 4. **Do** Job Sheet 1, "Diagnose and Troubleshoot Problems on the Steering Column and Steering Gear Assembly."

☐ 5. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 6. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Steps 3 and 4.

☐ 6. **Study** Information Sheet, Objectives 4 through 6.

☐ 7. **Do** Job Sheet 2, "Remove Steering Wheel, Inspect, Repair or Replace to Proper Alignment Position."

☐ 8. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 9. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Steps 6 and 7.

☐ 9. **Study** Information Sheet, Objectives 7 and 8.

☐ 10. **Do** Job Sheet 3, "Remove, Disassemble, and Remount the Steering Gear Assembly."

☐ 11. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 12. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Steps 9 and 10.

Learning Activities Sheet

☐ 12. **Study** Information Sheet, Objectives 9 through 12.

☐ 13. **Do** Job Sheet 4, "Perform Steering Gear Adjustments."

☐ 14. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 15. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 4 and repeat Steps 12 and 13.

☐ 15. **Do** Job Sheet 5, "Inspect and Replace Pitman Arm on Steering Gear Assembly."

☐ 16. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 18. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 5 and repeat Step 15.

Optional

☐ 17. **View** Videotape entitled "U-Joint Failures."

☐ 18. **Do** Job Sheet 6, "Inspect and Replace Steering U-Joints."

☐ 19. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 20 If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 6 and repeat Step 18.

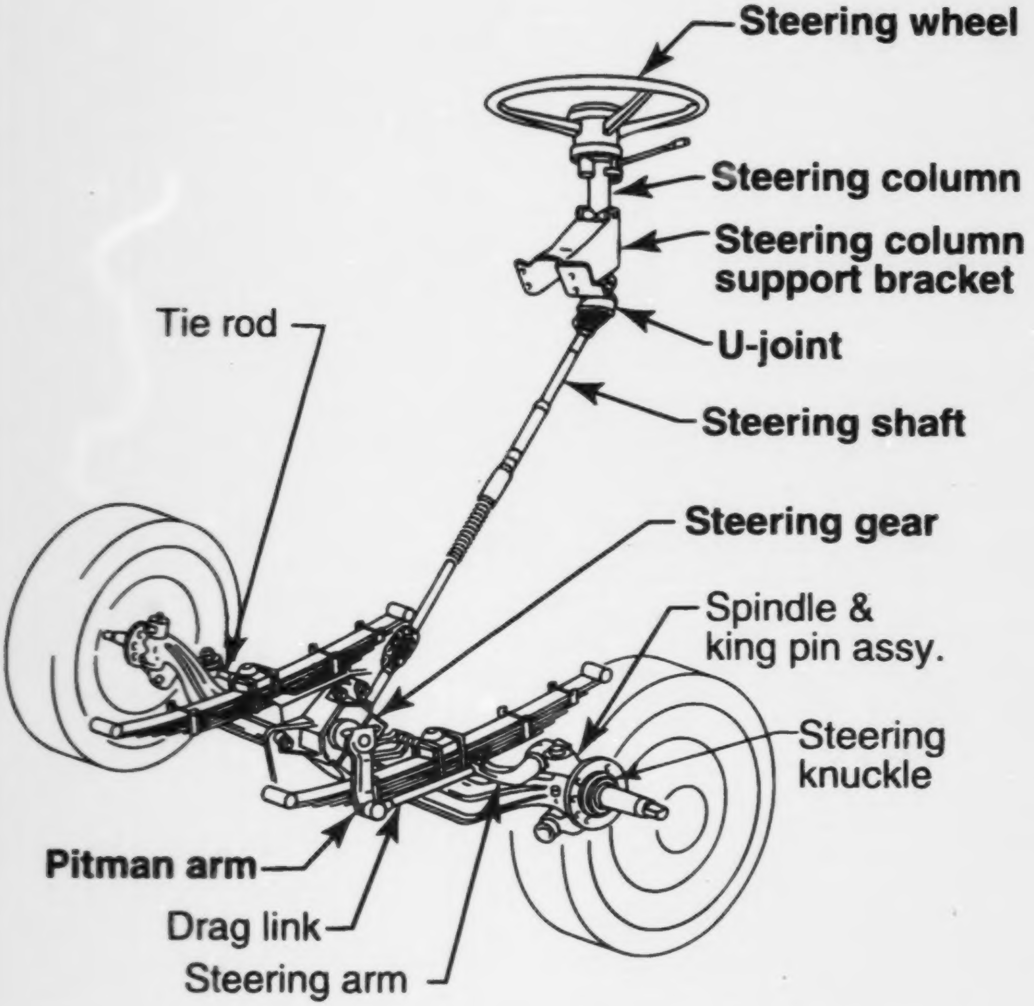
☐ 20. **Check** With instructor for any additional assignments to be completed.

☐ 21. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 22. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Parts of a Standard Steering Column and Manual Steering Gear Assembly


Steering wheel
Steering column
Steering column support bracket
U-joint
Tie rod
Steering shaft
Steering gear
Spindle & king pin assy.
Steering knuckle
Pitman arm
Drag link
Steering arm

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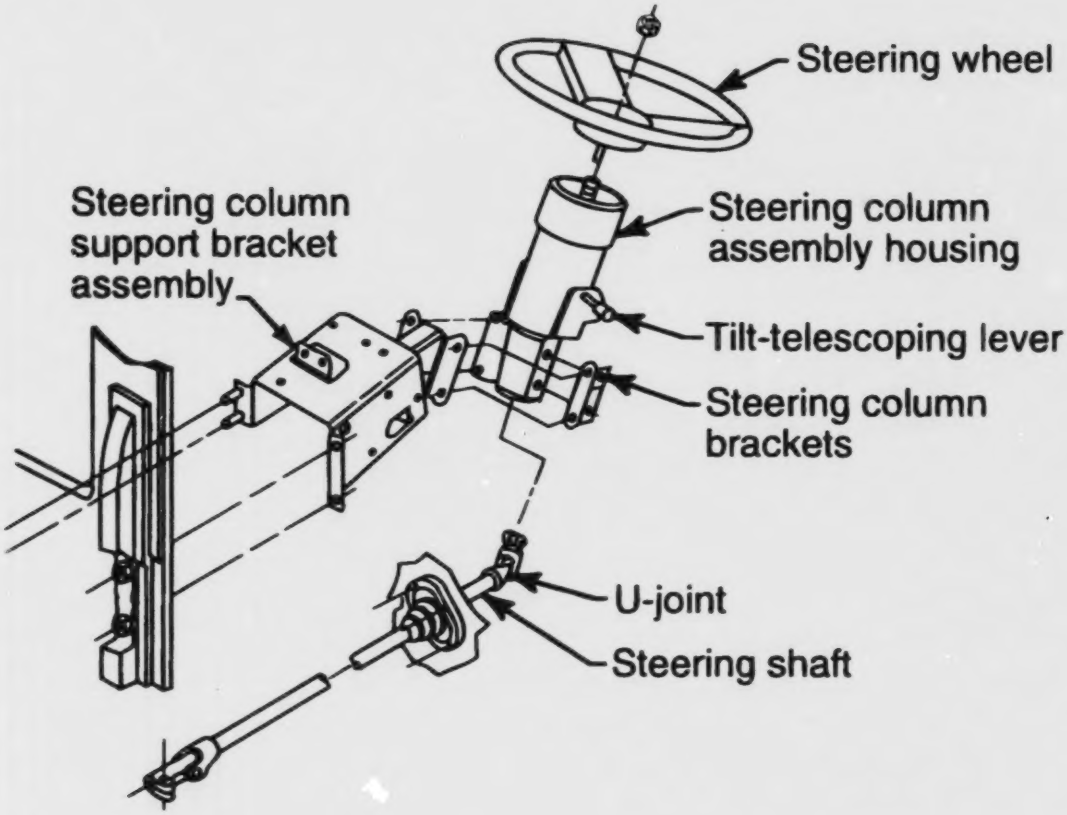
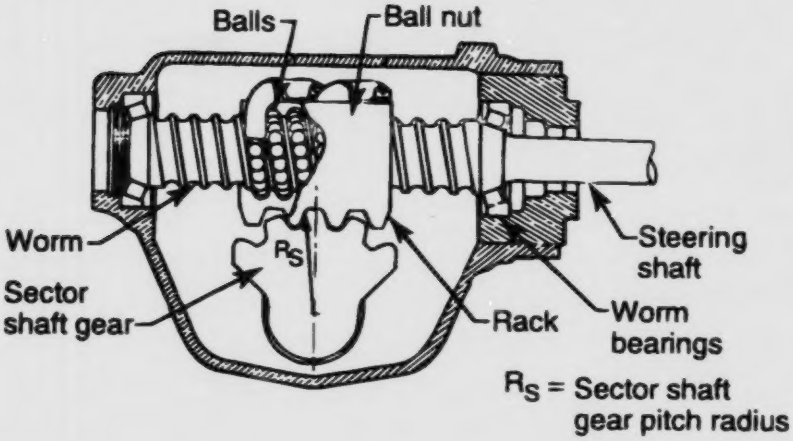
Parts of a Tilt/Telescoping Steering Column Assembly


Steering wheel
Steering column support bracket assembly
Steering column assembly housing
Tilt-telescoping lever
Steering column brackets
U-joint
Steering shaft

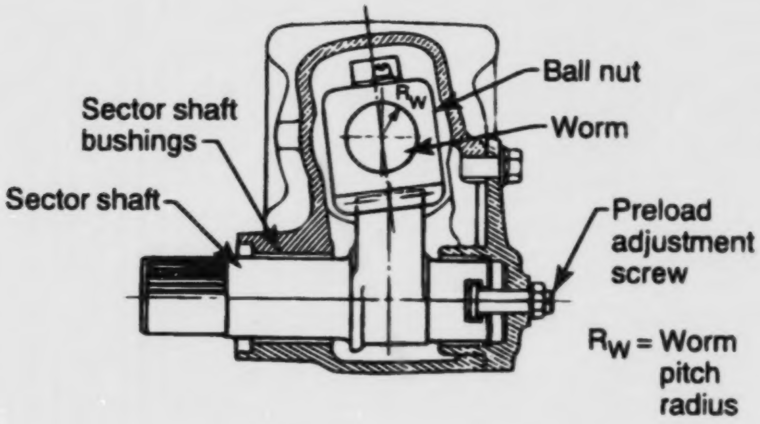
Courtesy of Navistar International Transportation Corp.

Parts of a Recirculating Ball Manual Steering Gear



Balls
Ball nut
Worm
R_S
Sector shaft gear
Rack
Steering shaft
Worm bearings
R_S = Sector shaft gear pitch radius

Side View



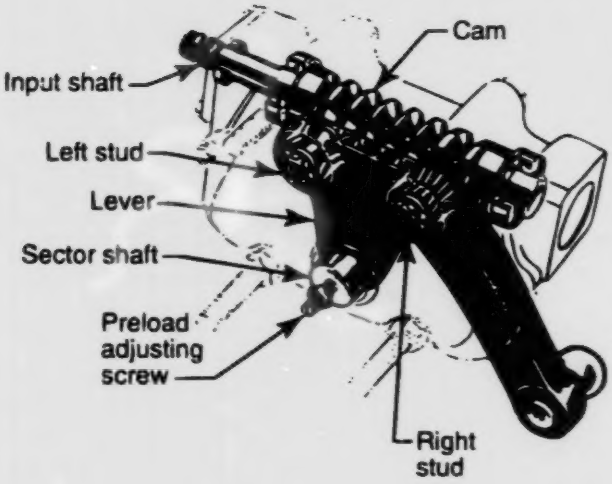
Ball nut
R_W
Worm
Sector shaft bushings
Sector shaft
Preload adjustment screw
R_W = Worm pitch radius

End View

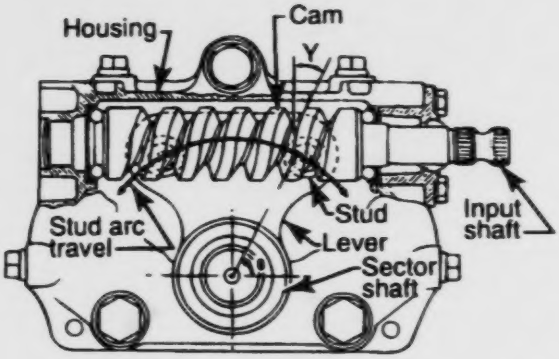
Courtesy of TRW Commercial Steering Division

TM 3

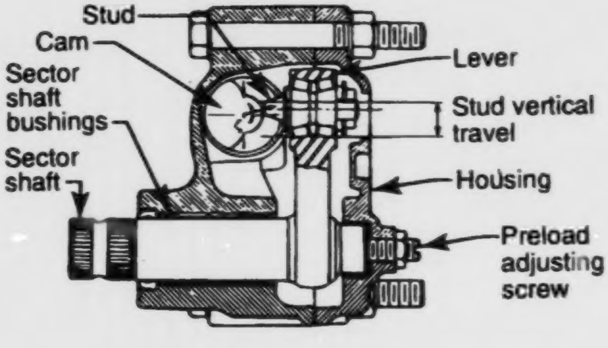
Parts of a Cam and Lever Manual Steering Gear


Cam
Input shaft
Left stud
Lever
Sector shaft
Preload adjusting screw
Right stud

Pictorial View


Housing
Cam
Y
Stud
Input shaft
Stud arc travel
Lever
Sector shaft

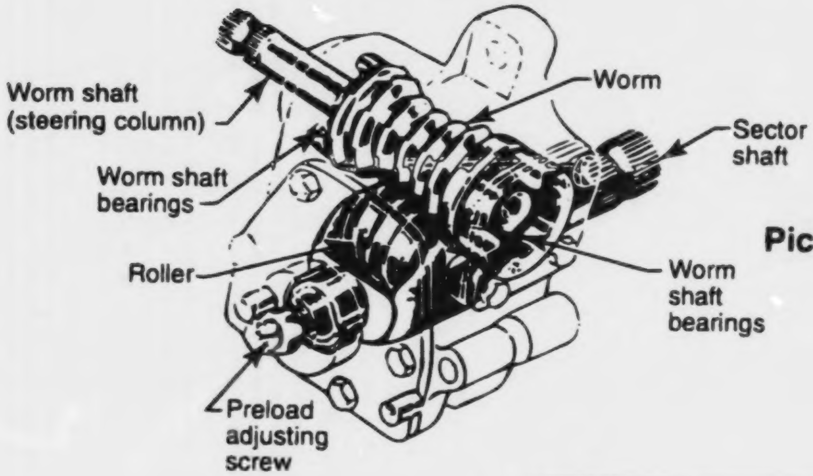
Side View


Stud
Cam
Lever
Sector shaft bushings
Stud vertical travel
Sector shaft
Housing
Preload adjusting screw

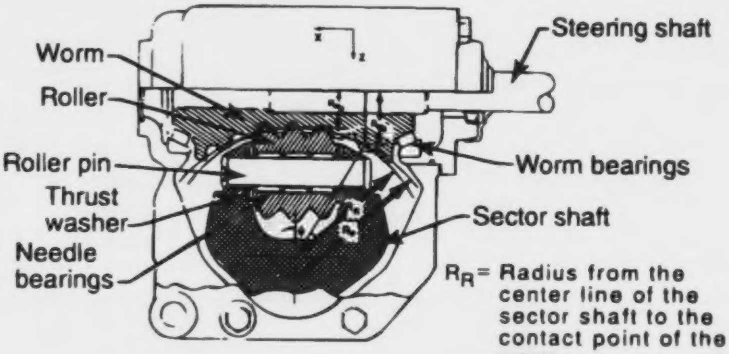
End View

Courtesy of TRW Commercial Steering Division

Parts of a Worm and Roller Steering Gear


Worm shaft (steering column)
Worm
Sector shaft
Worm shaft bearings
Roller
Worm shaft bearings
Preload adjusting screw

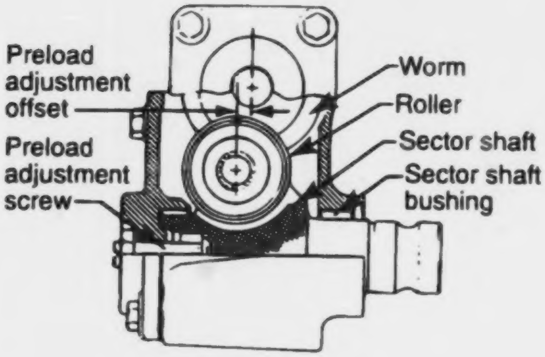
Pictorial View


Steering shaft
Worm
Roller
Roller pin
Worm bearings
Thrust washer
Sector shaft
Needle bearings

Side View

R_R = Radius from the center line of the sector shaft to the contact point of the worm

R_P = Radius of the worm pitch line


Preload adjustment offset
Worm
Roller
Sector shaft
Preload adjustment screw
Sector shaft bushing

End View

Courtesy of TRW Commercial Steering Division

Unit Contents

Teacher Components

Teacher Page

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Transparency Masters

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2—Parts of a Semi-Integral Power Steering System 2B-25
3—Power Steering Gear Operation 2B-27
4—Valve Operation 2B-29

Student Components

Student Page

Objective Sheet 2B-3

Information Sheet 2B-5

Job Sheets

1—Diagnose, Test, and Troubleshoot Problems on a Power Steering System 2B-19
2—Remove and Repair/Replace Power Steering Gear 2B-23
3—Rebuild Power Steering Gear 2B-27
4—Remove and Replace Power Steering Pump; Adjust Belt if Used 2B-31
5—Inspect, Clean, Disassemble, and Rebuild Power Steering Pump; Replace Worn Parts 2B-35
6—Test and Repair/Replace Flow Control/Pressure Relief Valve(s) on Power Steering Pump 2B-39
7—Fill and Bleed the Power Steering System 2B-43

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Have students identify the basic components of power steering systems using vehicles available in the shop. Have them describe each component's function in the overall system operation.

- Discuss the different types of power steering systems, and point out the advantages and disadvantages of each type.

- Construct a mock-up of a power steering system to show the basic operation of the steering gear and valve(s) as they move for right and left turns. Have students compare the different positions for turning right, left, and neutral. Give students hands-on practice time working the system.

- Provide disassembled or cutaway power steering gears and pumps so students can manipulate and understand their different parts and operation. Hands-on experience is very important, especially for tactile learners.

- Show examples of low pressure and high pressure lines used on power steering assemblies. Let students examine them to see the physical differences. Discuss the types of pressures used and why different types of lines are needed.

- Discuss the most common problems that you have encountered with power steering gears. Describe what may be required to solve each problem.

- Provide examples of power steering systems in need of repair and manufacturers' troubleshooting guides or service manuals for students to use in Job Sheet 1. You may want to also provide gears, pumps, and valves with simple problems for students to practice on prior to Job Sheet 1.

- Make sure the appropriate tools, equipment, and service manuals are available for students to use in the job sheets.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.

- Reteach and retest as required.

Suggested Activities

Resources Used in Developing This Unit

Print Media

- *Chilton's Heavy Duty Truck Service Manual.* Radnor, PA: Chilton Book Company, 1992.
- *Freightliner FLA COE & FLD Conventional Service Manual (Section 46).* Portland, OR: Freightliner Corporation, 1990.
- *GM/GMC Service Manual* (X-7735). Pontiac, MI: GM Truck and Coach Division, 1977.
- *Hydrapower Integral Power Steering Gear HF54 Service Manual.* Lafayette, IN: TRW Ross Gear Division, 1986.
- *Navistar Service Manual, CTS-4078.* Chicago: Navistar International Transportation Corp., 1994.
- Norman, Ian Andrew, Robert Scharff, and John A. Corinchock. *Heavy Duty Truck Systems,* 2nd edition. Albany, NY: Delmar Publishers, 1996.

Suggested Supplemental Resources

Print Media

- *Medium Duty Truck Power Steering System Training Course (93001.00).* This one-day course covers the principles of operation, diagnosis, on-vehicle service, and overhaul of medium duty truck steering gears (Saginaw and TRW Ross) and power steering pumps (Saginaw and Hobourn). Contact your local GM/GMC Truck dealer for more information about course dates and locations. A GM Training Materials Catalog is available from:

  General Motors Training Materials
  Mascotech Mktg. Service
  1972 Brown Road
  Auburn Hills, MI 48326
  1-800-393-4831

- *Total Service Package.* Includes a complete set of service manuals and service bulletins for TRW steering gears and components, as well as the *Chart Your Way to Easy Steering Video Kit* and the *TAS Poppet Video Kit.*

  The above, as well as Ross service manuals, are available from:

  TRW/Ross Gear Division—Commercial Steering
  P.O. Box 60
  800 Heath Street
  Lafayette, IN 47902-0060
  1-317-429-1923

- *Sheppard Power Steering Gears Service Manual* (1000485)
- *Sheppard M Series Power Steering Gears Service Manual* (1000791)
- *Ross HF64 Power Steering Gear Service Manual* (HF64-111)
- *Ross HFB64 Power Steering Gear Service Manual* (HFB64-108)
- *Ross HFB70 Power Steering Gear Service Manual* (HFB70-109)
- *Ross TAS Series Power Steering Gear Service Manual* (TAS-2)

The above are available from your local Mack Truck service center or contact:

Mack Trucks, Inc.
2100 Mack Blvd.
P.O. Box M
Allentown, PA 18105-5000
1-610-439-3011

Electronic Media

- *Chart Your Way to Easy Steering Video Kit*—Includes two videotapes, troubleshooting guide, diagnostic flowcharts, and a grease pencil for diagnosing the ten most common driver complaints.

The above, as well as Ross service manuals, are available from:

TRW/Ross Gear Division—Commercial Steering
P.O. Box 60
800 Heath Street
Lafayette, IN 47902-0060
1-317-429-1923

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match terms related to power steering systems with their definitions.

1. Integral
2. Power steering assembly
3. Power steering gear
4. Power steering hydraulic tester
5. Remote
6. Steering gear

_____ a. Device used to test, troubleshoot, and adjust hydraulics in power steering system

_____ b. Formed as a unit with another part

_____ c. Steering mechanism powered by hydraulic pressure

_____ d. Mechanism that moves (steers) the vehicle's wheels

_____ e. Collection of parts combined for the purpose of power steering

_____ f. One part operating at some distance removed from the other part(s)

Objective 2

Select from the following list the purposes of power steering systems by placing an "X" in the blanks next to the true statements.

_____ a. To increase operator's steering effort

_____ b. To increase steering control

_____ c. To increase steering response

_____ d. To increase power of engine

_____ e. To decrease tire wear

Written Test

Objective 3

Match basic components of a power steering assembly with their functions.

1. Flow control valve
2. Power steering gear
3. Power steering lines
4. Power steering pump
5. Pressure relief valve
6. Reservoir

_____ a. Converts mechanical energy from the engine into hydraulic energy to give power to the steering system

_____ b. Holds the power steering fluid

_____ c. Limits the hydraulic pressure built up when the steering gear is turned against its stops; relieves excess pressure

_____ d. Assists the mechanical steering with hydraulic fluid under pressure directed to one or the other side of the piston (depending on whether a right or left turn is being made)

_____ e. Regulates the constant flow of fluid from the pump as it varies with the demands of the steering gear

_____ f. Conduct hydraulic fluid from reservoir to pump, through rest of system to power steering gear, and then back to reservoir

Objective 4

Describe the basic differences between manual steering and power steering.

a. ____

____

b. ____

____

Objective 5

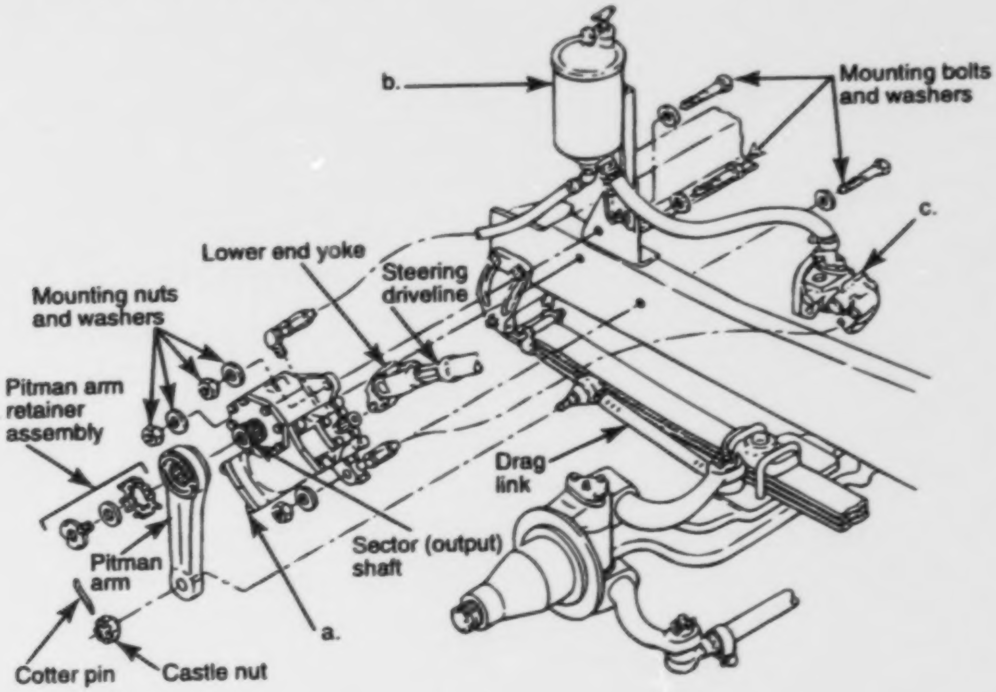
Distinguish between the common types of power steering systems by placing the following letters next to the correct descriptions:

I = next to integral power steering systems
S = next to semi-integral power steering systems

_____ a. Consists of a gear box (manual steering mechanism and hydraulic control valve) with hydraulic lines connected to remote hydraulic power cylinder(s)

_____ b. All power steering components are contained in a compact gear box

Objective 6 Identify the following parts of an integral power steering assembly.


b.
Mounting bolts and washers
c.
Lower end yoke
Steering driveline
Mounting nuts and washers
Pitman arm retainer assembly
Drag link
Sector (output) shaft
Pitman arm
a.
Cotter pin
Castle nut

Courtesy of Freightliner Corporation

a. ______________________________

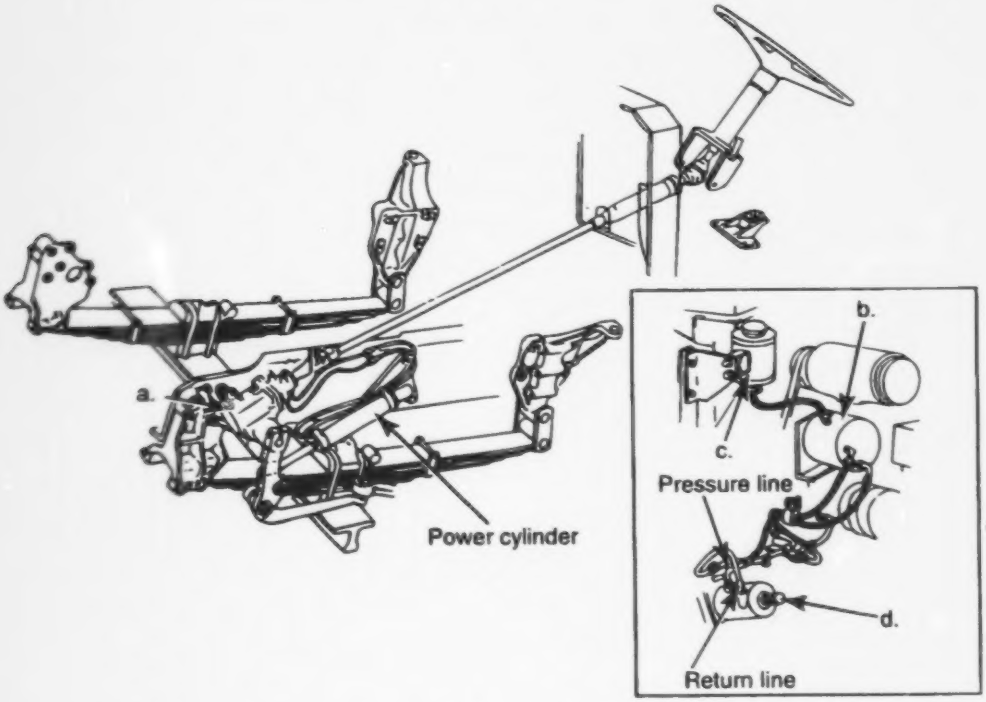
b. ______________________________

c. ______________________________

BEST COPY AVAILABLE

Written Test

Objective 7 Identify the following parts of a semi-integral power steering assembly.


a.
Power cylinder
b.
c.
Pressure line
d.
Return line

Courtesy of General Motors Corporation, Service Technology Group

a. ______________________________

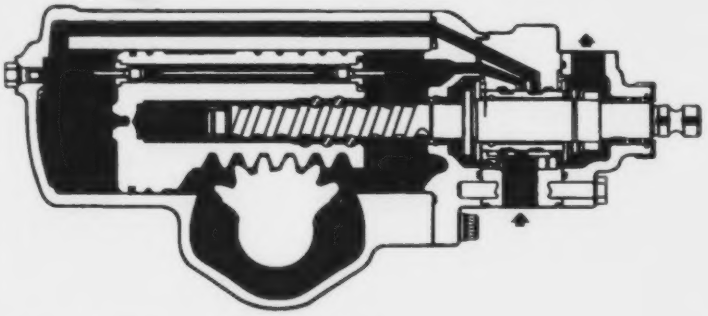
b. ______________________________

c. ______________________________

d. ______________________________

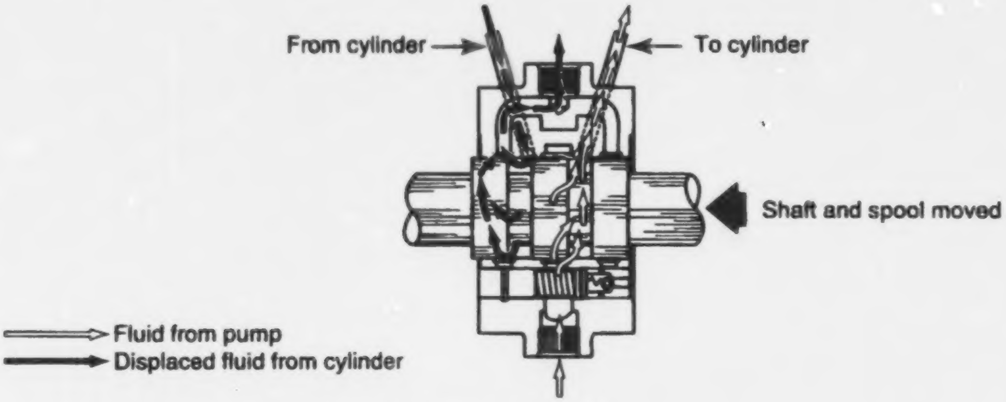
Objective 8

Identify power steering gear and valve operation flow for right turn, neutral position, and left turn steering maneuvers. Write your answers in the blanks provided.



Courtesy of TRW Commercial Steering Division

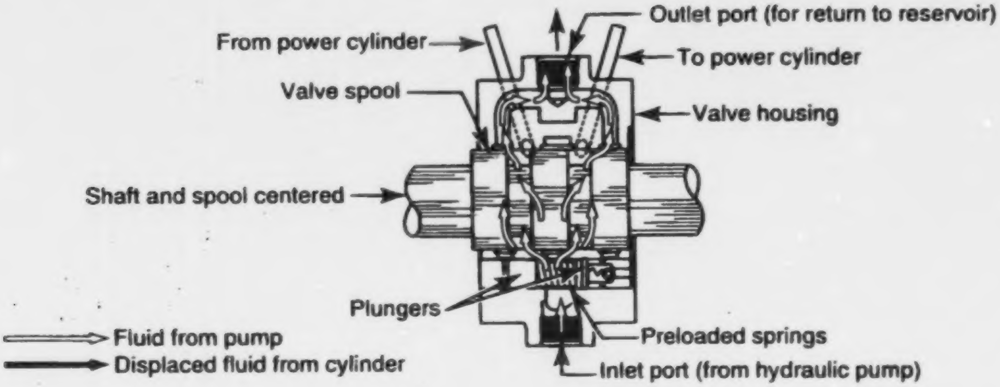
a. ______________________


From cylinder
To cylinder
Shaft and spool moved
Fluid from pump
Displaced fluid from cylinder

Courtesy of TRW Commercial Steering Division

b. ______________________

Written Test



Outlet port (for return to reservoir)
From power cylinder
To power cylinder
Valve spool
Valve housing
Shaft and spool centered
Plungers
Preloaded springs
Fluid from pump
Displaced fluid from cylinder
Inlet port (from hydraulic pump)

Courtesy of TRW Commercial Steering Division

c. ____________________

Objective 9

Name two common types of lubricants used in power steering systems.

a. ____________________

b. ____________________

Objective 10

Distinguish between the types of lines used on power steering assemblies by placing the following letters next to the correct descriptions:

L = next to low pressure lines
H = next to high pressure lines

_____ a. For suction and return line from gear or valve back to reservoir; fiber- or cloth-reinforced line

_____ b. From pump to steering gear or valve; for delivering pressurized hydraulic fluid; wire-reinforced line

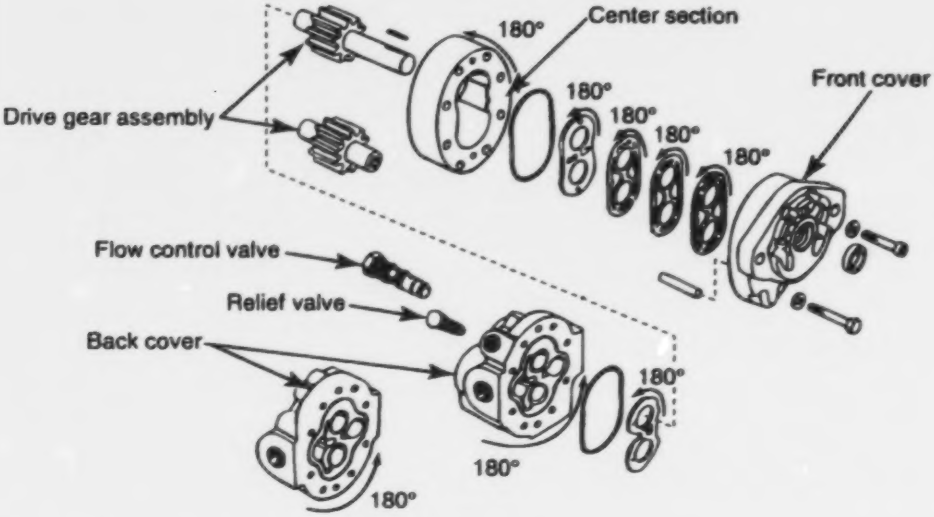
Objective 11

List two basic types of power steering reservoirs

a. ____________________

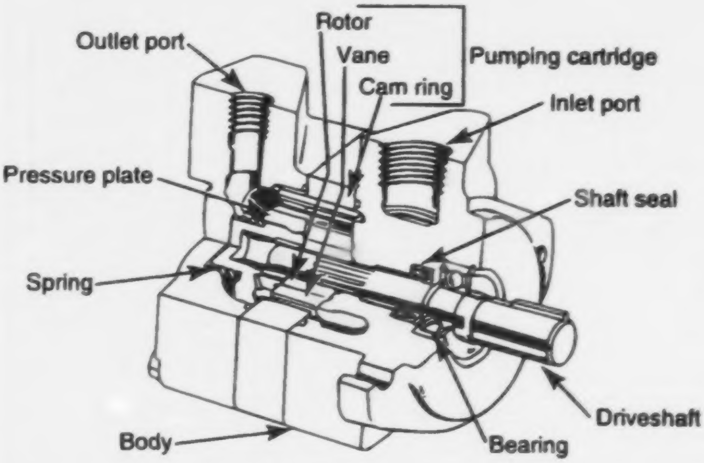
b. ____________________

Objective 12 Identify the following types of hydraulic pumps used on power steering systems.


180°
Center section
Front cover
Drive gear assembly
180°
180°
180°
180°
Flow control valve
Relief valve
Back cover
180°
180°
180°

Courtesy of Navistar International Transportation Corp.

a. ____________________


Rotor
Vane
Cam ring
Pumping cartridge
Outlet port
Inlet port
Pressure plate
Shaft seal
Spring
Driveshaft
Body
Bearing

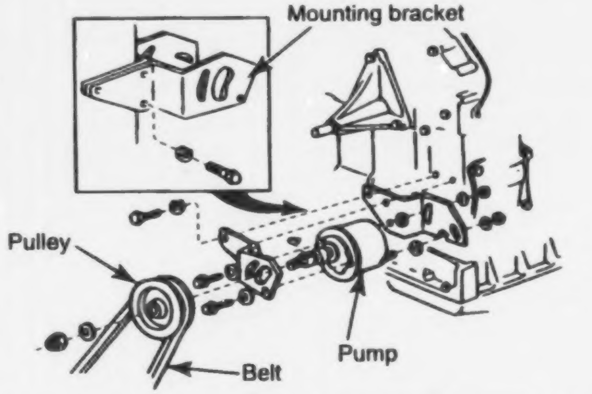
Courtesy of Freightliner Corporation

b. ____________________

Written Test

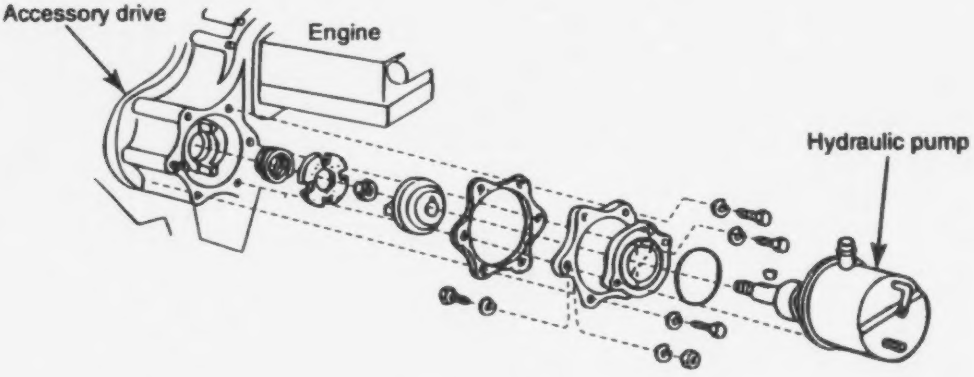
Objective 13

Identify the two means of mounting power steering pumps.


Mounting bracket
Pulley
Belt
Pump

Courtesy of General Motors Corporation, Service Technology Group

a. ______________________


Accessory drive
Engine
Hydraulic pump

Courtesy of General Motors Corporation, Service Technology Group

b. ______________________

Objective 14 Complete the following chart of common pump problems and possible causes. List at least one possible cause for each problem listed.

Problems	Possible Causes
Steering pump leaks	
Fluid being forced out of steering reservoir	
Fluid is discolored or smells burned	
Abnormal or too much noise	

*Permission to duplicate this test is granted.

Answers to Written Test

Objective 1

a. 4
b. 1
c. 3
d. 6
e. 2
f. 5

Objective 2

b, c

Objective 3

a. 4
b. 6
c. 5
d. 2
e. 1
f. 3

Objective 4

Descriptions should include the following:

a. Power steering takes power from the engine to assist in the turning effort. Manual steering relies only on the driver's effort to operate the steering gear.
b. Power steering and manual steering have the same basic components (steering wheel, steering column, steering gear), but power steering adds hydraulic lines and the hydraulic pump to deliver hydraulic fluid under pressure to the steering gear.

Objective 5

a. S
b. I

Objective 6

a. Steering gear
b. Power steering reservoir
c. Power steering pump

Objective 7

a. Steering gear
b. Hydraulic pump
c. Reservoir
d. Control valve

Objective 8

a. Gear in neutral
b. Valve position and fluid flow for right turn
c. Neutral valve position and fluid flow

Objective 9

Any two of the following:

a. Multiviscosity motor oil (10W40)
b. Dexron III (automatic transmission fluid)
c. Power steering fluid (type recommended by vehicle manufacturer)

Objective 10

a. L
b. H

Answers to Written Test

Objective 11

a. Built onto the pump
b. Remotely mounted

Objective 12

a. Gear pump
b. Vane pump

Objective 13

a. Remote mounted
b. Direct mounted

Objective 14

Any one cause for each of the following problems:

Problems	**Possible Causes**
Steering pump leaks	—Damaged hoses, loose or damaged fittings —Leaking seals
Fluid being forced out of steering reservoir	—Temperature too high —Clogged filter in reservoir —Air in system —Pump is damaged
Fluid is discolored or smells burned	—Temperature too high —Interval between fluid changes is too long —Unapproved fluid used
Abnormal or too much noise	—Fluid lines contacting other vehicle parts —Loose parts —Air in system or low fluid level —Foreign material in system —Worn or damaged pump

Unit 2-B Power Steering Systems

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 7

☐ 4. **Do** Job Sheet 1, "Diagnose, Test, and Troubleshoot Problems on a Power Steering System."

☐ 5. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 6. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Steps 3 and 4.

☐ 6. **Do** Job Sheet 2, "Remove and Repair/Replace Power Steering Gear."

☐ 7. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 8. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 6.

☐ 8. **Study** Information Sheet, Objectives 8 through 10.

☐ 9. **Do** Job Sheet 3, "Rebuild Power Steering Gear."

☐ 10. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 11. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Steps 8 and 9.

☐ 11. **Study** Information Sheet, Objectives 11 through 14.

☐ 12. **Do** Job Sheet 4, "Remove and Replace Power Steering Pump; Adjust Belt If Used."

☐ 13. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 14. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 4 and repeat Steps 11 and 12.

☐ 14. **Do** Job Sheet 5, "Inspect, Clean, Disassemble, and Rebuild Power Steering Pump; Replace Worn Parts."

☐ 15. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 16. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 5 and repeat Step 14.

☐ 16. **Do** Job Sheet 6, "Test and Repair/Replace Flow Control/Pressure Relief Valve(s) on Power Steering Pump."

☐ 17. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 18. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 6 and repeat Step 16.

☐ 18. **Do** Job Sheet 7, "Fill and Bleed the Power Steering System."

☐ 19. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 20. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 7 and repeat Step 18.

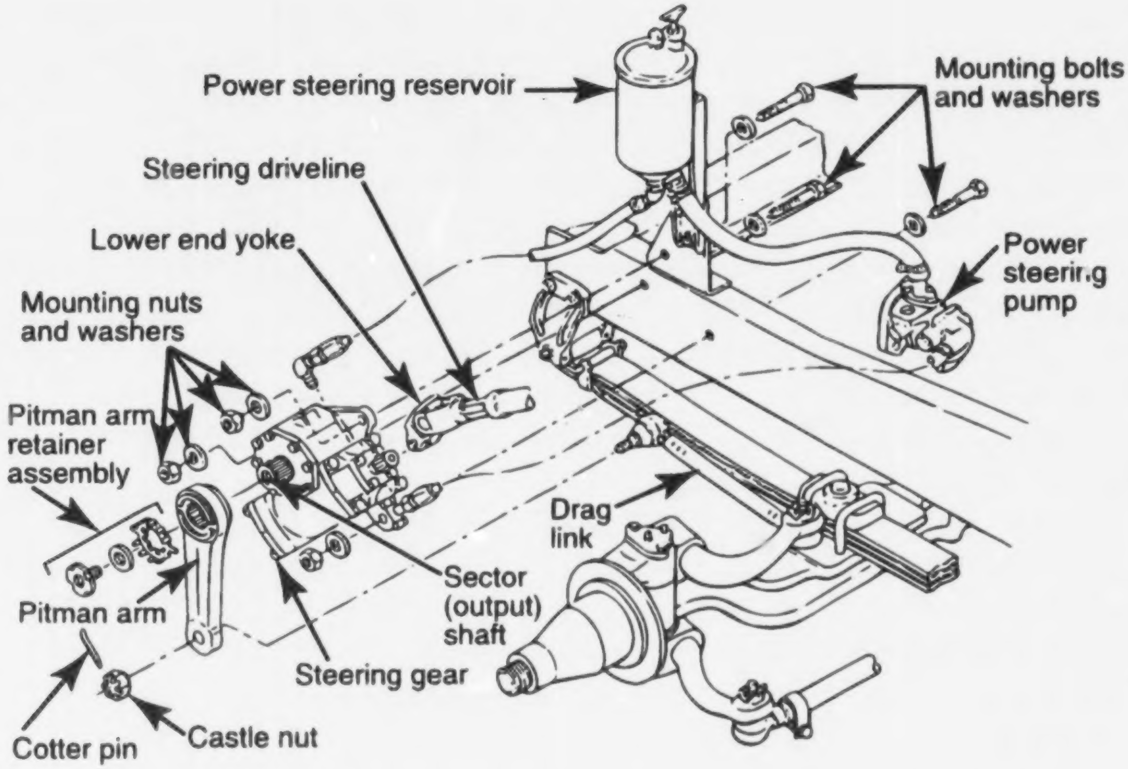
☐ 20. **Check** With instructor for any additional assignments to be completed.

☐ 21. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 22. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

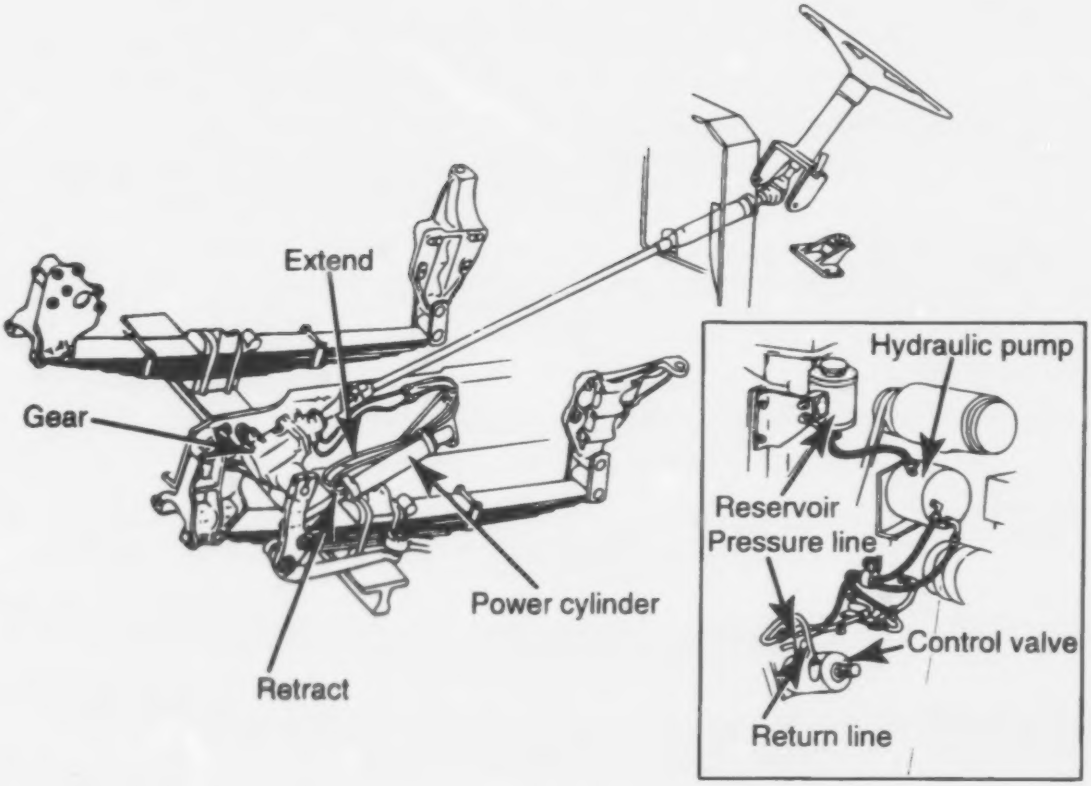
***Permission to duplicate this form is granted.**

Parts of an Integral Power Steering System


Power steering reservoir
Mounting bolts and washers
Steering driveline
Lower end yoke
Power steering pump
Mounting nuts and washers
Pitman arm retainer assembly
Drag link
Sector (output) shaft
Pitman arm
Steering gear
Cotter pin
Castle nut

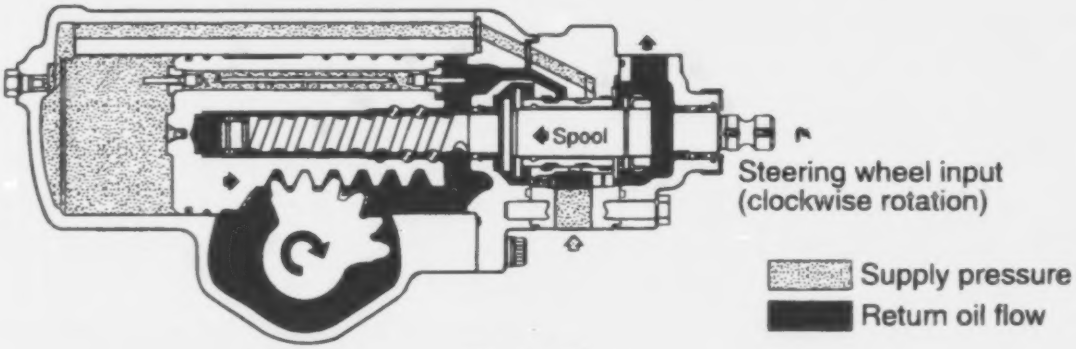
Courtesy of Freightliner Corporation

Parts of a Semi-Integral Power Steering System

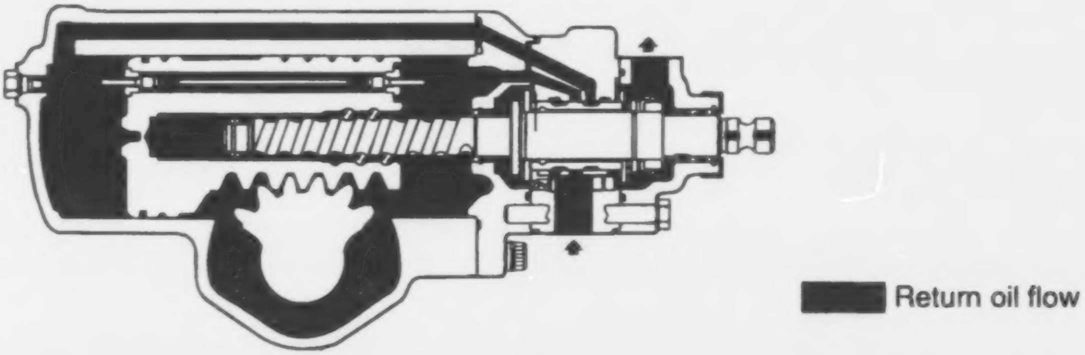

Extend
Gear
Power cylinder
Retract
Hydraulic pump
Reservoir
Pressure line
Control valve
Return line

Courtesy of General Motors Corporation, Service Technology Group

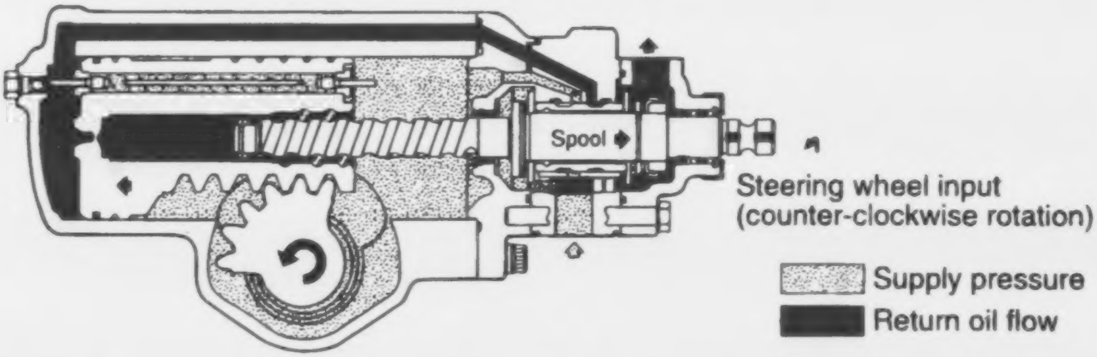
Power Steering Gear Operation


Spool
Steering wheel input
(clockwise rotation)
▨ Supply pressure
■ Return oil flow

Right Turn


■ Return oil flow

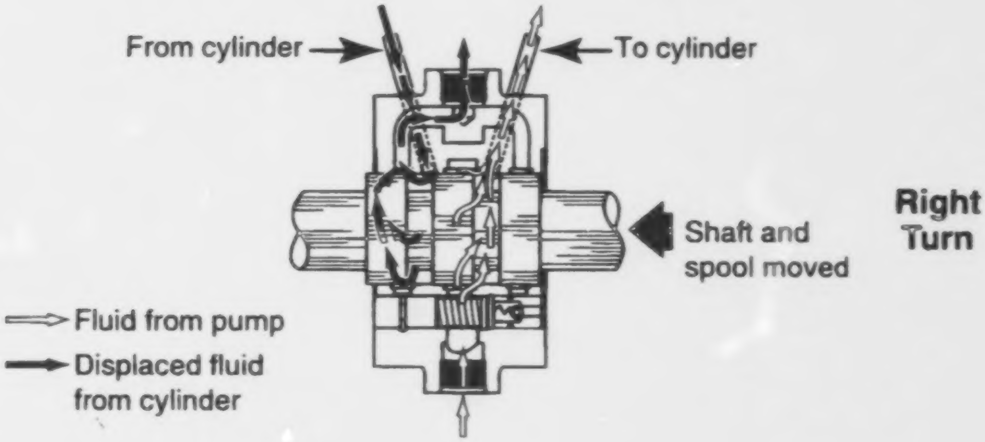
Neutral

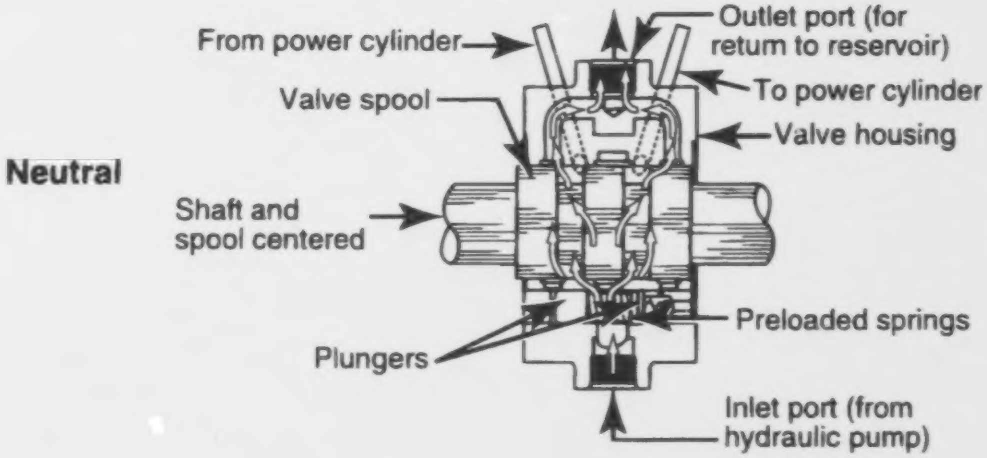

Spool
Steering wheel input
(counter-clockwise rotation)
▨ Supply pressure
■ Return oil flow

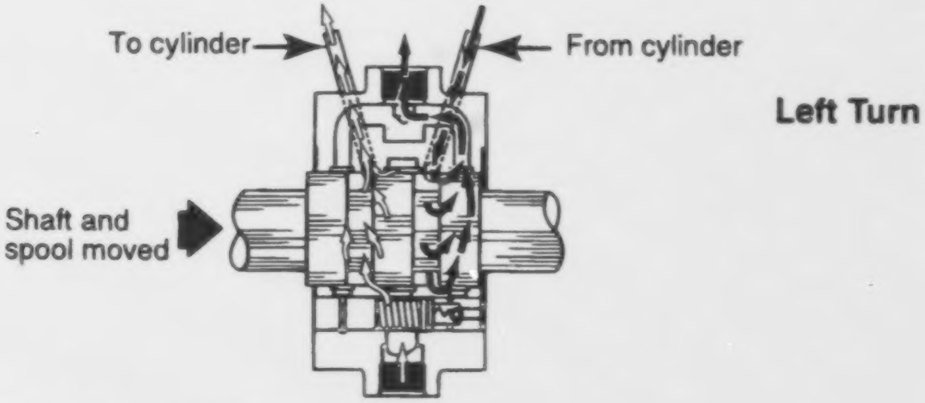
Left Turn

Courtesy of TRW Commercial Steering Division

Valve Operation


From cylinder
To cylinder
Right Turn
Shaft and spool moved
Fluid from pump
Displaced fluid from cylinder


From power cylinder
Outlet port (for return to reservoir)
To power cylinder
Valve spool
Valve housing
Neutral
Shaft and spool centered
Preloaded springs
Plungers
Inlet port (from hydraulic pump)


To cylinder
From cylinder
Left Turn
Shaft and spool moved

Courtesy of TRW Commercial Steering Division

Unit 3-B Steering Axle Components

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 3B–3

Written Test 3B–9

Answers to Written Test 3B–17

Learning Activities Sheet 3B–21

Transparency Masters

  1—Typical Steering Axle Components 3B–23
  2—Parts of a Steering Knuckle Assembly 3B–25
  3—Parts of a Wheel Bearing 3B–27

Student Components

Student Page

Objective Sheet 3B–3

Information Sheet 3B–5

Assignment Sheet

  1—Select Wheel Bearings and Seals 3B–19

Job Sheets

  1—Remove, Inspect, Clean, Replace, and Adjust Wheel Bearings and Seals 3B–21
  2—Repair or Replace Steering Knuckle Assembly 3B–25
  3—Inspect and Replace Tie Rod Ends 3B–29
  4—Diagnose and Troubleshoot the Steering Axle Assembly 3B–33

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheet. Review with students the criteria for evaluation of this activity.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Have students identify the basic steering axle components using vehicles available in the shop. Have them describe each component's function in the overall system operation.
- Construct a mock-up of steering linkage components to show the basic movements involved in right and left turns. Have students compare the different positions for turning right, left, and neutral. Give students hands-on practice time working the mock-up.
- Show examples of steering knuckle assemblies. Let students practice disassembling and assembling the components.
- Discuss the most common problems that you have encountered with steering axle components. Describe what may be required to solve each problem.
- Show examples of the common wheel bearings and seals. Discuss precautions and guidelines for installing and adjusting them.
- Construct a display of damaged wheel bearings. Have students identify the different types of defects. Also have them name one possible cause of the defect.
- Provide examples of steering axle components in need of repair and manufacturers' troubleshooting guides or service manuals for students to use in Job Sheet 4.
- Make sure the appropriate tools, equipment, and service manuals are available for students to use in the job sheets.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the assignment sheet. Rate the student using the criteria listed on the assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.

- Reteach and retest as required.

Suggested Activities

Resources Used in Developing This Unit

Print Media

- *Fundamental of Service: Bearings and Seals.* Moline, IL: Deere & Company, 1992.
- *International Truck Service Manuals,* CTS-2006Q, CTS-4010E, and CTS-5026. Chicago: Navistar International Transportation Corporation.
- Schultz, Erich J. *Diesel Equipment I and II.* New York: McGraw-Hill Book Company, 1982.
- *Sheppard Power Steering Service Manual.* Hanover, PA: R. H. Sheppard Company.
- *Spicer Maintenance Manual,* SHAD 887-1-25C. Fort Wayne, IN: Spicer Heavy Axle Division/Dana Corporation.

Suggested Supplemental Resources

Print Media

- *How to Install Seals Instruction Manual (#457809)*

  The above is available from:

  CR Services
  735 Tollgate Road
  Elgin, IL 60123
  800-882-0008 or 847-742-7840

- *Wheel Bearing Adjustment Procedure Wall Chart* (T0400). 24″ x 36″. Describes consistent method of achieving a verifiable wheel bearing end play of 0.001″ to 0.005″. Procedure applies to steer, drive, and trailer-axle assemblies using conventional double-nut or single-nut systems.
- *Wheel Bearing Adjustment Procedure Pocket Reference* (T0420). Same information as wall chart above in a handy, pocket-sized format.

  The above are available from:

  American Trucking Associations
  Customer Services Dept.
  2200 Mill Road
  Alexandria, VA 22314-4677
  1-800-ATA-LINE

- *Wheel Bearings Service Manual* (15-701). Available from your local Mack Truck service center or contact:

  Mack Trucks, Inc.
  2100 Mack Blvd.
  P.O. Box M
  Allentown, PA 18105-5000
  1-610-439-3011

- Wall charts—color

  — *Proper Installation of National Oil Bath Seals*

  — *Proper Installation of Wheel Bearings*

  — *Anti-Friction Bearing Distress Analysis*

  The wall charts listed above are available from your local Federal-Mogul dealer or contact the national headquarters:

  Federal-Mogul Corporation
  26555 Northwestern
  Southfield, MI 48034
  1-810-354-7700

Electronic Media

- *CR Bearings Videotape (#457296)*

  The above is available from:

  CR Services
  735 Tollgate Road
  Elgin, IL 60123
  800-882-0008 or 847-742-7840

- *Computer Wheel Balancers*, 20-minute videotape. Available from your local Snap-On Tool Representative or call 1-800-756-3344 to order.

- *Wheel Bearing Adjustment Procedure*, 16-minute videotape (T-89158V). Available from:

  Rockwell International Corporation
  2135 West Maple Road
  Troy, MI 48084
  1-800-535-5560

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms related to steering axle components with their definitions. Definitions continue on the next page.

1. Bearing
2. Drag link
3. Endplay
4. Journal
5. Kingpin
6. Packing
7. Pitman arm
8. Preload
9. Press fit
10. Races
11. Seal
12. Spindle
13. Steering axle
14. Tie rods
15. Tie rod assembly
16. Wheel and hub assembly
17. Wheel bearing

_____ a. Three-piece construction, consisting of a tie rod and two tie rod end assemblies; the ends are threaded to the rod and locked with clamp bolts

_____ b. Part that helps spread the forces of a load to reduce the friction and wear of a moving part

_____ c. Cast rod or tube connecting the pitman arm to the steering knuckle assembly

_____ d. Tracks or channels in which something rolls or slides

_____ e. Amount of lateral movement of the hub along the spindle due to clearance in the bearings

_____ f. Small shaft or axle on which a wheel turns; also called steering knuckle

_____ g. Bearing used to distribute the load of a vehicle on its axles

_____ h. Material used to form a leak proof connection between moving or fixed parts

_____ i. That part of a shaft, axle, or spindle that turns in a bearing

_____ j. Act of forcing grease into wheel bearings

_____ k. Assembly consisting of tire, rim, hub, bearings, and other components mounted on an axle in such a way that it rotates to allow movement of a vehicle

Written Test

_____ l. Adjustment of bearings so that there is a slight load on them to ensure proper internal alignment and limiting of endplay

_____ m. Metal connecting bars that are threaded with left and right hand end threads which provide for toe-in adjustment

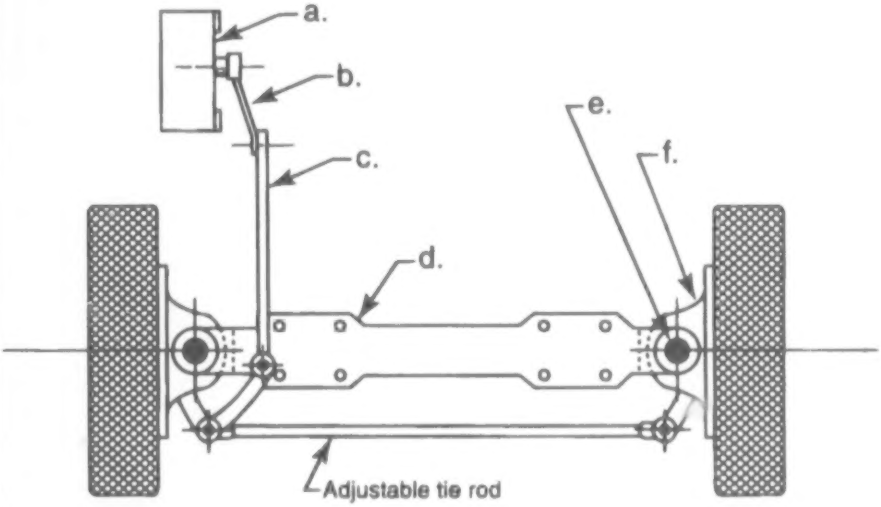
_____ n. Arm that connects steering gear to drag link

_____ o. Heat-treated forged steel I-beam with integral spring seats

Objective 2

Identify the following steering axle components. Write your answers in the blanks provided.

Figure 1



Courtesy of Navistar International Transportation Corp.

a. ____________________ d. ____________________

b. ____________________ e. ____________________

c. ____________________ f. ____________________

Objective 3

Complete statements concerning steering linkage by filling in the blanks with the correct answers.

a. Steering gear is connected to the drag link by the ____________________.

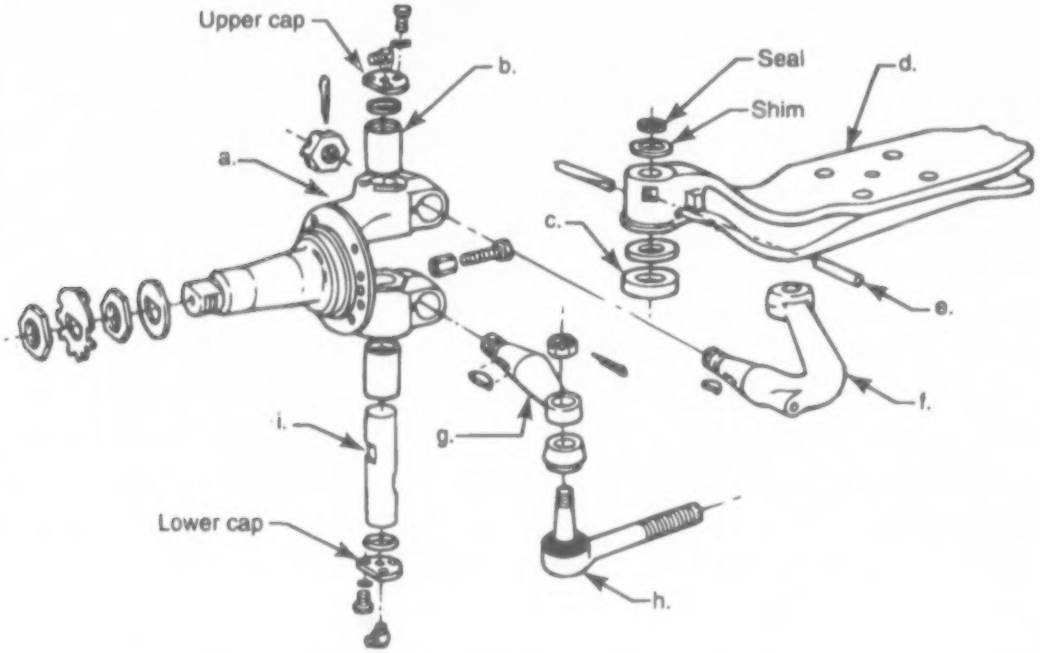
b. When steering gear is activated for right turn, the direction of steering linkage movement is ____________________.

c. When steering gear is activated for left turn, the direction of steering linkage movement is ____________________.

Objective 4

Identify the following steering knuckle assembly. Write your answers in the blanks provided.

Figure 2



Courtesy of Navistar International Transportation Corp.

a. ______________________

b. ______________________

c. ______________________

d. ______________________

e. ______________________

f. ______________________

g. ______________________

h. ______________________

i. ______________________

Objective 5

Distinguish between lubricants used on steering axle components by placing the following letters next to the correct descriptions:

M = next to multipurpose lithium grease meeting NLG1-1 or 2 specifications
S = next to synthetic lubricants compatible with API GL-5

_____ a. For oil-lubricated wheel bearings on heavy duty axles.

_____ b. For kingpins and tie rod ends (if equipped with lube fittings) and for grease-lubricated wheel bearings.

Written Test

Objective 6

Complete the following chart of typical steering axle problems and causes.

PROBLEMS	POSSIBLE CAUSES
a. Hard steering	1. __________ 2. __________
b. Truck wanders	1. __________ 2. __________
c. Truck pulls to one side	1. __________ 2. __________
d. Worn kingpins and knuckle bushings	1. __________ 2. __________

Objective 7

List two purposes of wheel bearings.

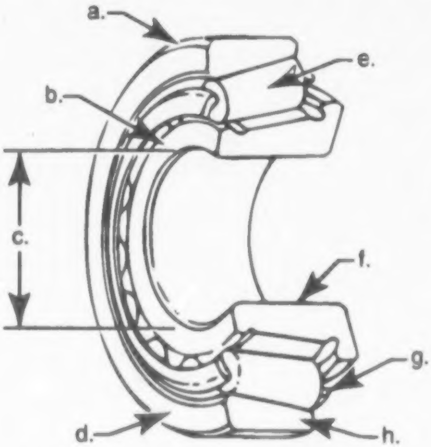
a. ____________________

b. ____________________

Objective 8

Identify the following parts of a wheel bearing. Write your answers in the blanks provided.

Figure 3



Used with permission of Deere and Company, Moline, Illinois.

a. ______________________ e. ______________________

b. ______________________ f. ______________________

c. ______________________ g. ______________________

d. ______________________ h. ______________________

Objective 9

Match wheel bearing defects with their descriptions. Descriptions continue on the next page.

1. Abrasive roller wear
2. Abrasive step wear
3. Brinelling
4. Etching
5. Frettage
6. Galling
7. Heat discoloration
8. Indentations
9. Mechanical damage
10. Misalignment
11. Smearing
12. Spalling
13. Stain discoloration

_____ a. Metal smears on the ends of the rollers, usually caused by overheating from inadequate lubrication or overloading; the bearing must be replaced

_____ b. Improper fit of bearing assembly parts due to improper installation or excessive pressure from a foreign object in the hub, usually evidenced by uneven wear of the races; the bearing must be replaced if the wear is excessive or if the bearing is damaged

_____ c. Corrosion and spotty wear caused by relatively small movements of poorly lubricated parts; replace bearings

_____ d. Metal smears on the surface of the races due to slippage as a result of improper fit, poor lubrication, overloading, or rough handling; replace bearings

_____ e. Deforming or breaking of the bearing assembly as a result of mechanical stress such as rough handling or improper fit; the bearing must be replaced

_____ f. Wear patterns on the rollers and race from contamination by the abrasives; bearing can be reused if wear is minor

_____ g. Discoloration ranging from faint yellow to dark blue as a result of inadequate lubrication or overloading; replace the bearings

_____ h. Flaking of the surface metal from metal fatigue or poor quality bearings; replace bearings

_____ i. Gray or black discoloration of race and roller surfaces, usually with scuffing of the surfaces in patterns parallel to the rollers and generally caused by loose fitting of the bearings; generally requires replacement of bearings

_____ j. Surface indentations in the raceway that parallel the rollers caused by excessive loading or vibration while the bearing is not rotating; generally requires replacement of the bearing

Objective 10

Complete statements concerning servicing wheel bearings by circling the correct answers.

a. Follow the (**bearing, vehicle**) manufacturer's recommendations for the selection and installation of wheel bearings.

b. Follow the (**bearing, vehicle**) manufacturer's instructions for the selection and installation of lubricant.

c. Every wheel has (**two, four**) sets of bearings. Be sure you don't install these backwards.

d. Use only an approved (**detergent, solvent**) to clean bearings.

e. If compressed air is used to clean bearings, use only (**low, high**) pressure.

f. Observe (**asbestos exposure, bloodborne pathogen**) precautions because brake linings and other components may be contaminated.

g. If the condition of a bearing, seal, or other component is in doubt, (**reuse, replace**) it.

Objective 11

Distinguish between correct and incorrect guidelines for adjusting wheel bearings by placing the following letters next to the correct descriptions:

C — next to correct guidelines
I — next to incorrect guidelines

_____ a. Follow vehicle service manual procedure to adjust bearings.

_____ b. Adjust all bearings with preload.

_____ c. Use a dial indicator to adjust endplay.

_____ d. Adjust endplay to .05". Check service manual for specifications.

_____ e. While adjusting bearings, make sure that brakes do not drag on drum or rotor to produce a false adjustment.

_____ f. Make preliminary adjustment by tightening spindle (adjusting) nut to torque recommended by service manual.

_____ g. Rotate wheel in only one direction while tightening to ensure that bearing is seated.

_____ h. To align locking device, back nut off spindle from initial torque setting by ⅙ to ⅓ turn (depending on manufacturer) to align with nearest locking hole. Wheel should rotate freely.

_____ i. Always reuse locking devices (such as cotter pins and washers with tangs)

Objective 12

List two purposes of wheel seals.

a. ______________________________

b. ______________________________

Objective 13

List one type of wheel seal for each category

a. One-piece — ______________________________

b. Multipiece — ______________________________

Written Test

Objective 14

Complete statements concerning installing wheel seals by filling in the blanks with the correct answers.

a. Take care when prying out the old seal not to ____________________ the housing

b. Inspect the bore and shaft for ____________________ that could cut the new seal.

c. Check shaft and bore dimensions to make sure they match the ____________________ specifications.

d. Excessively worn or grooved shafts may be fitted with ____________________ to create a new seal running surface.

e. Never ____________________ old or damaged seals.

f. Make sure the new seal faces in the correct direction; usually the lip ____________________ the lubricant or fluid to be retained.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 15
b. 1
c. 2
d. 10
e. 3
f. 12
g. 17
h. 11
i. 4
j. 6
k. 16
l. 8
m. 14
n. 7
o. 13

Objective 2

a. Steering gear
b. Pitman arm
c. Drag link
d. Steering axle
e. Kingpin
f. Steering knuckle assembly

Objective 3

a. Pitman arm
b. Right
c. Left

Objective 4

a. Axle knuckle
b. Upper bushing
c. Thrust bushing
d. Axle I beam
e. Draw key
f. Steering arm
g. Ackermann arm
h. Tie rod end
i. Kingpin

Objective 5

a. S
b. M

Answers to Written Test

Objective 6

Student should state two causes for each problem given.

PROBLEMS	POSSIBLE CAUSES
Hard steering	1. Low tire pressure 2. Low pressure in power steering system 3. Improper front end alignment 4. Insufficient lubrication 5. Bent steering knuckle or linkage 6. Worn steering gear or linkage 7. Steering column misalignment
Truck wanders	1. Incorrect front end alignment 2. Broken spring 3. Tight steering gear or linkage 4. Loose spring shackles 5. Unequal tire inflation
Truck pulls to one side	1. Dragging brake 2. Tight or dry wheel bearing 3. Unequal tire inflation 4. Unequal caster (it will pull to side with less caster)
Worn kingpins and knuckle bushings	1. Worn or missing seals and gaskets 2. Incorrect lubricant 3. Lack of lubrication or not following correct procedure or scheduled frequency

Objective 7

Any two of the following:

a. To spread the weight of the vehicle and its load over a greater surface
b. To reduce the friction of wheel rotation
c. To reduce wear to parts
d. To provide a replaceable wear surface

Objective 8

a. Outer race
b. Inner race
c. Bore
d. Face
e. Roller
f. Cone
g. Separator
h. Cup

Objective 9

a. 6
b. 10
c. 5
d. 11
e. 9
f. 1
g. 7
h. 12
i. 4
j. 3

BEST COPY AVAILABLE

Objective 10

a. Vehicle
b. Bearing
c. Two
d. Solvent
e. Low
f. Asbestos exposure
g. Replace

Objective 11

a. C
b. I
c. C
d. I
e. C
f. C
g. I
h. C
i. I

Objective 12

Any two of the following:

a. To retain lubricants or liquids
b. To exclude dirt, water, and other contaminants
c. To separate dissimilar fluids (such as lubricating oil and water)
d. To confine pressure

Objective 13

One of each of the following categories:

a. One-piece
  - Unitized
  - Barrier
b. Multipiece
  - Lip seal
  - Wear rings

Objective 14

a. Scratch (or damage)
b. Nicks or burrs
c. Seal
d. Wear (repair) sleeves
e. Reuse
f. Faces

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 7 through 14.

Optional

☐ 4. **View** Videotapes entitled "CR Bearings," and "Wheel Bearing Adjustment Procedure."

☐ 5. **Do** Assignment Sheet 1, "Select Wheel Bearings and Seals."

☐ 6. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to Step 7. If the evaluation is not satisfactory, repeat Steps 3 and 5.

☐ 7. **Do** Job Sheet 1, "Remove, Inspect, Clean, Replace, and Adjust Wheel Bearings and Seals."

☐ 8. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 9. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Step 7.

☐ 9. **Study** Information Sheet, Objective 4.

☐ 10. **Do** Job Sheet 2, "Repair or Replace a Steering Knuckle Assembly."

☐ 11. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 12. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Steps 9 and 10.

Learning Activities Sheet

☐ 12. **Study** Information Sheet, Objectives 5 and 6.

☐ 13. **Do** Job Sheet 3, "Inspect and Replace Tie Rod Ends."

☐ 14. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 15. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Steps 12 and 13.

☐ 15. **Study** Information Sheet, Objectives 1 and 2.

☐ 16. **Do** Job Sheet 4, "Diagnose and Troubleshoot the Steering Axle Assembly."

☐ 17. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 18. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 4 and repeat Steps 15 and 16.

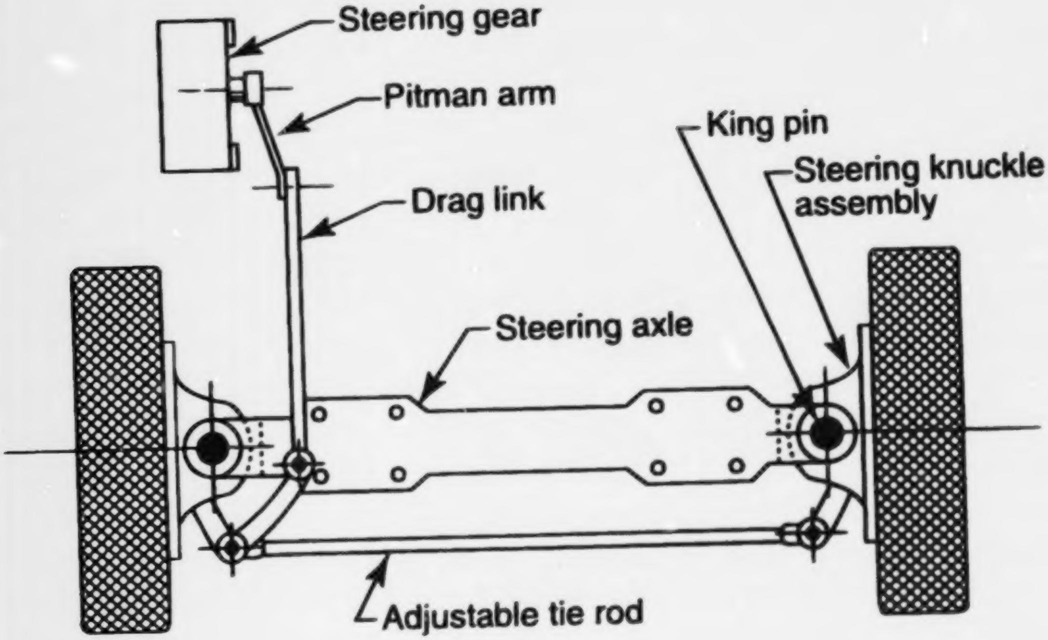
☐ 18. **Check** With instructor for any additional assignments to be completed.

☐ 19. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 20. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

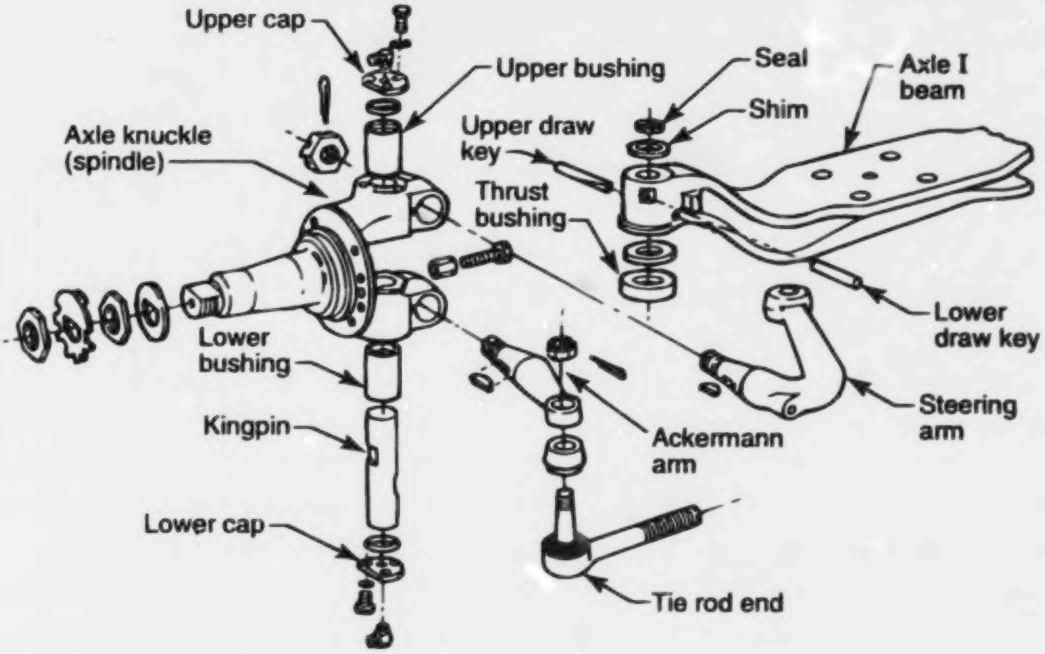
Typical Steering Axle Components


Steering gear
Pitman arm
King pin
Steering knuckle assembly
Drag link
Steering axle
Adjustable tie rod

Courtesy of Navistar International Transportation Corp.

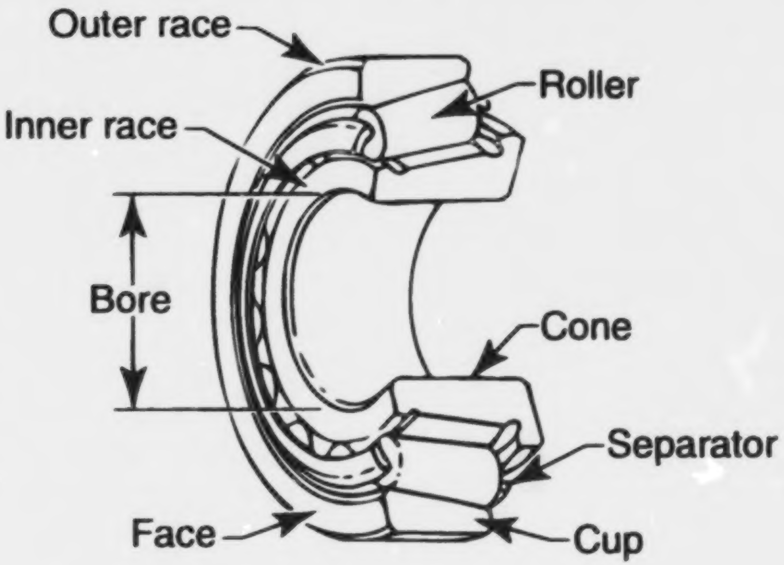
TM 1

Parts of a Steering Knuckle Assembly


Upper cap
Upper bushing
Seal
Axle I beam
Shim
Axle knuckle (spindle)
Upper draw key
Thrust bushing
Lower bushing
Lower draw key
Steering arm
Kingpin
Ackermann arm
Lower cap
Tie rod end

Courtesy of Navistar International Transportation Corp.

Parts of a Wheel Bearing


Outer race
Roller
Inner race
Bore
Cone
Separator
Face
Cup

Note: Tapered roller bearing is shown.

Courtesy of Deere and Company, Moline, Illinois

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Unit Contents

Teacher Page

Teacher Components

Suggested Activities 1C–3

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Answers to Written Test 1C–15

Learning Activities Sheet 1C–17

Transparency Masters

1—Front Suspension Components 1C–19
2—Basic Designs of Springs 1C–21
3—Types of Spring Assembly Ends 1C–23
4—Dimensions of Spring Assemblies 1C–25
5—Types of Spring Eyes 1C–27
6—Shapes of U-Bolts 1C–29
7—Dimensions of U-Bolts 1C–31

Student Page

Student Components

Objective Sheet 1C–3

Information Sheet 1C–5

Job Sheets

1—Inspect Front Suspension Components 1C–15
2—Remove and Replace Front Spring Suspension Components . . 1C–19

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Have students identify the basic components of front suspensions using vehicles available in the shop. Have them describe each component's function in the overall system operation.
- Show students the types of wear that occur on front suspension components. Discuss the causes of the wear and what can be done to remedy the problems.
- Discuss the different types of spring designs (stepped or tapered leaf) and point out the advantages and disadvantages of each type.
- Show examples of spring assembly ends, all three types if possible—eyes on both ends, eye and hook, and eye and pad. If not all types are available in the shop, use sales brochures or service manuals for illustrations.
- Have students practice measuring the required dimensions on spring assemblies. Then provide parts catalogs so they could locate the appropriate spring assemblies for replacements.
- Provide actual examples of various shapes of u-bolts and have students identify them according to their shapes. Then have them measure the required dimensions for replacements and look up the correct parts in catalogs.
- Provide actual examples of shock absorbers (new and old) and have students practice identifying and measuring them, determining whether or not they are good or bad, and locating appropriate replacements.
- Demonstrate how to use a radius gauge.
- Discuss safety precautions to follow when working on suspensions. Tell about any accidents you have seen or been involved in as they relate to suspension work. Also discuss what students should do in case of an accident.
- Make sure the appropriate tools, equipment, and service manuals are available for students to use in the job sheets.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Suggested Activities

Resources Used in Developing This Unit

Print Media

- *Batco Suspension Manual (#107)*. Dallas: Brake, Axle, and Tandem Company (BATCO).
- *Dayton Parts Catalog (#2—Suspension Components)*. Harrisburg, PA: Dayton Parts Inc.
- *Dayton Self-Study Course #2—Spring Identification*. Harrisburg, PA: Dayton Parts Inc.
- *Euclid Parts Catalog, Volumes III and IV.* Cleveland, OH: Euclid Industries, Inc.
- *Hunter Advanced Heavy Truck and Trailer Alignment Course Guide*. St. Paul: Hunter Engineering Company.
- Norman, Ian Andrew, et al. *Heavy-Duty Truck Systems*, 2nd ed. Albany, NY: Delmar Publishers, 1996.
- *Peterbilt Maintenance Manual (for Models 379, 377, 375, 357, and 355) (Catalog #5290)*. Newark, CA: Peterbilt Motors Company, 1987.
- Schultz, Erich J. *Diesel Equipment I and II*. New York: McGraw-Hill Book Company, 1982.

Suggested Supplemental Resources

Print Media

- Reyco offers several training programs on their tractor/trailer suspensions, as well as service bulletins on their suspension, brake drum, and wheel hub products. For more information about training programs/courses or to request service bulletins, contact:

  Reyco Industries, Inc.
  Field Service Dept.
  600 N. Prospect
  Springfield, MO 65802
  1-417-862-4343

Electronic Media

- *769C-793B Off-Highway Trucks—Suspension System*, 29 slides (SEGV2599), textbook (SEBV2599), and student materials (SEEV2599). Available from your local CAT dealer or write the following for more information:

  Caterpillar Service Training
  600 W. Washington St., Bldg. JJ
  East Peoria, IL 61630

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms with their definitions.

1. Axle rating
2. Axle seat
3. Constant rate spring
4. Jounce
5. Leaf
6. Leaf spring
7. Radius
8. Rebound
9. Spring rate
10. Sprung weight
11. Unsprung weight

_____ a. One thin sheet or plate of an object

_____ b. Leaf spring that deflects at a constant rate as load is added

_____ c. Amount of weight the axle is approved to carry

_____ d. Weight of the vehicle that is supported by the springs

_____ e. Upward flexing (compression) of the spring as it absorbs energy while a wheel is going over a bump

_____ f. Flat machined area of axle where the spring rests; contains two holes for each u-bolt and one blind hole for the center bolt head

_____ g. Downward flexing of the spring as it releases energy while the wheel returns to its normal position

_____ h. Weight that is not supported by the springs; includes the axle, tires, rims, brakes, and some of the steering components

_____ i. Special type of elastic or resilient device (spring) made up of stacked strips or leaves

_____ j. Distance from the center to the edge of a circle; one half of the diameter

Objective 2

State three purposes of front suspension.

a. ______________________________

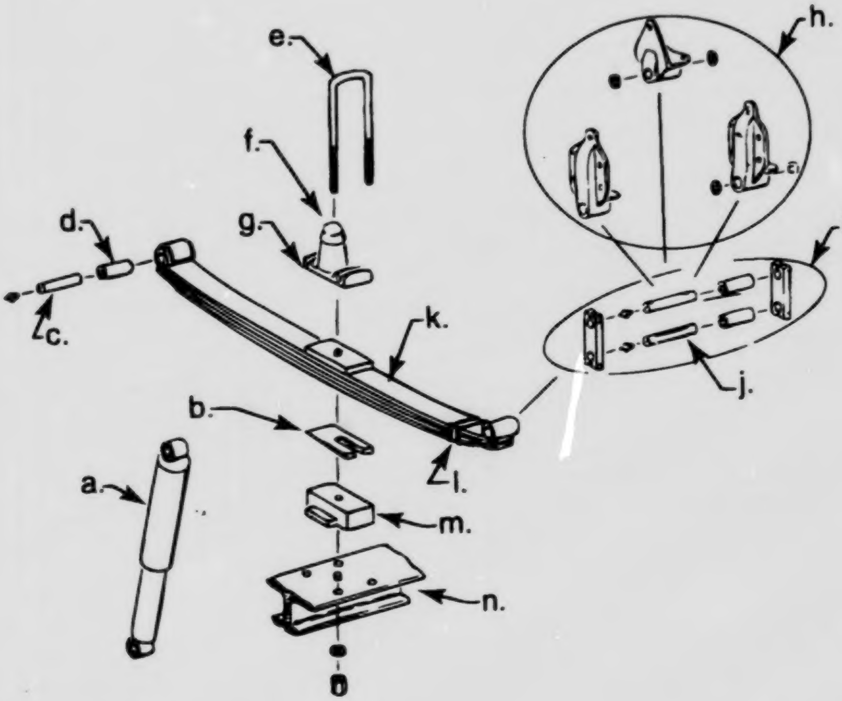
b. ______________________________

c. ______________________________

Written Test

Objective 3

Identify front suspension components. Write your answers in the blanks provided.



Courtesy of Dayton Parts Inc.

a. ______________________ h. ______________________

b. ______________________ i. ______________________

c. ______________________ j. ______________________

d. ______________________ k. ______________________

e. ______________________ l. ______________________

f. ______________________ m. ______________________

g. ______________________ n. ______________________

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Written Test

Objective 4

Match front suspension components with their functions and characteristics.

1. Bushings
2. Caster adjustment shims
3. Front hanger bracket
4. Leaf spring assembly
5. Rubber axle stop
6. Shackle assembly
7. Shackle hanger brackets
8. Shackle pins
9. Shock absorber brackets
10. Shock absorbers
11. Spacer block
12. Spring clips
13. Spring eye pin
14. U-bolts
15. U-bolt saddle

_____ a. Used to adjust the axle caster (rearward tilt of the kingpins)

_____ b. Hold the spring assembly to the axle seat

_____ c. Make the last part of the joint between the rear of the spring and the frame

_____ d. Attaches the front of the leaf spring assembly to the frame

_____ e. Prevent the spring from over flexing during rebound and thus dampen the spring oscillations which would otherwise occur

_____ f. Passes through holes in the front hanger bracket and the spring eye, allowing the spring assembly to pivot inside the bracket

_____ g. Used to prevent excessive flexing of the spring if the front wheels should encounter a large bump

_____ h. Forms the connection between the rear of the spring and the rear hanger bracket

_____ i. Form the joint between the shock absorber and the frame at the top and between the shock and the axle at the bottom

_____ j. Locates the tops of the u-bolts and distributes their clamping force over a larger area

_____ k. Provide a bearing surface between the eye of the spring and the pin

_____ l. May be used to achieve the desired frame height with a particular spring arch/wheel size combination

_____ m. Pass through the rear spring eye and the shackle side links forming a flexible joint

_____ n. Absorbs, stores, and then releases energy as the vehicle passes over bumps

_____ o. Used to prevent individual leaves from spreading sideways

Written Test

Objective 5

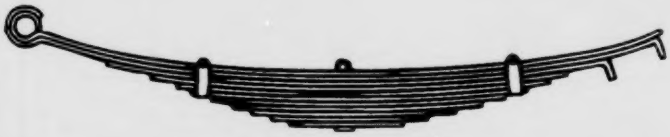
Distinguish between basic designs of springs by placing an "S" next to stepped spring designs and a "T" next to tapered leaf spring designs.

_____ a. Spring assembly consisting of a stack of spring leaves with the shortest leaf placed on the bottom and each successive leaf longer which helps to distribute the stress evenly

_____ b. Spring assembly consisting of a stack of full-length leaves in which each leaf is tapered in thickness to distribute the stress evenly

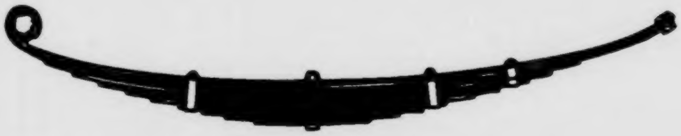
Objective 6

Identify the following types of front spring assembly ends. Write your answers in the blanks provided.



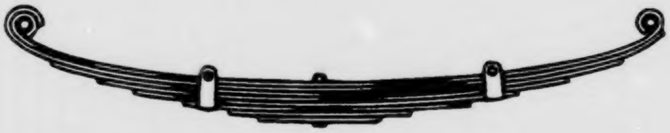
Courtesy of Dayton Parts Inc.

a. ______________________



Courtesy of Dayton Parts Inc.

b. ______________________

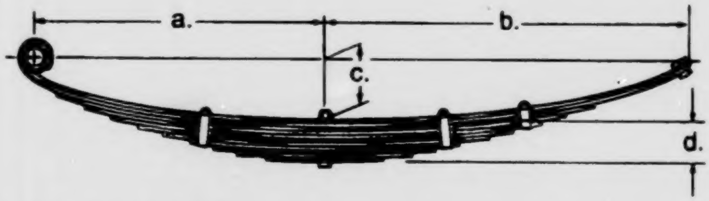


Courtesy of Dayton Parts Inc.

c. ______________________

Objective 7

Complete statements concerning dimensions and load ratings of spring assemblies. Write your answers in the blanks provided.



Courtesy of Dayton Parts Inc.

a. ____________________

b. ____________________

c. ____________________

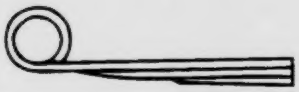
d. ____________________

e. Load rating is a function of length, width, number of leaves, and type of steel and is calculated by ____________________

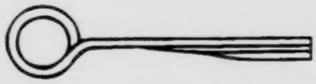
f. Load rating is often ____________________ on new springs.

Objective 8

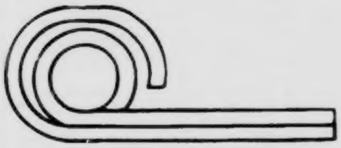
Identify the following types of spring eyes. Write your answers in the blanks provided.



a. ____________________



b. ____________________

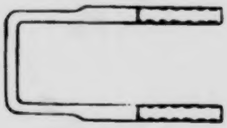


a. ____________________

Written Test

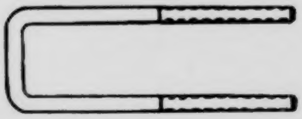
Objective 9

Identify the following shapes of U-bolts. Write your answers in the blanks provided.



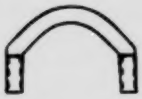
Courtesy of BATCO

a. ______________________



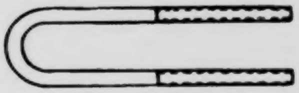
Courtesy of BATCO

b. ______________________



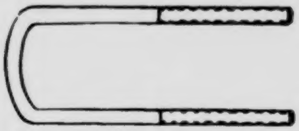
Courtesy of BATCO

c. ______________________



Courtesy of BATCO

d. ______________________



Courtesy of BATCO

e. ______________________

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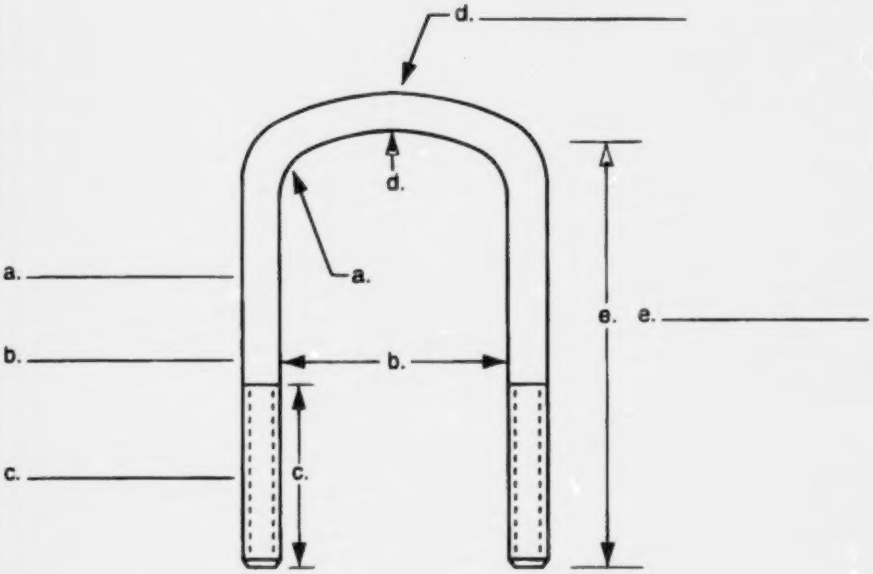
Objective 10

Label the dimensions of U-bolts. Write your answers in the blanks provided.



Courtesy of BATCO

Objective 11

Complete statements concerning the identification and measurement of shock absorbers by filling in the blanks with the correct answers.

a. Shock absorbers may be identified by the number ____________ on the shock absorber tube or dust cover.

b. If the number is not readable, identify the shock as follows:

  1) Collapsed or ____________ length

  2) Rubber bushing inside ____________

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a.	5	f.	2
b.	3	g.	8
c.	1	h.	11
d.	10	i.	6
e.	4	j.	7

Objective 2

Any three of the following:

a. To support the weight of the vehicle
b. To cushion the frame and cab of the vehicle from road shocks
c. To transfer braking forces to the frame
d. To maintain axle alignment

Objective 3

a. Shock absorber
b. Caster adjustment shim
c. Spring eye pin
d. Bushing
e. U-bolt
f. Rubber axle stop
g. U-bolt saddle
h. Shackle hanger brackets
i. Shackle assembly
j. Shackle pins
k. Leaf spring assembly
l. Spring clip
m. Spacer block
n. Axle seat

Objective 4

a.	2	e.	10	i.	9	m.	8
b.	14	f.	13	j.	15	n.	4
c.	7	g.	5	k.	1	o.	12
d.	3	h.	6	l.	11		

Objective 5

a.	S
b.	T

Objective 6

a. Eye and hook
b. Eye and pad
c. Eyes on both ends

Answers to Written Test

Objective 7

a. Length of short-end
b. Length of long-end
c. Arch
d. Pad thickness
e. The manufacturer
f. Stenciled

Objective 8

a. Berlin eye
b. Upturned eye
c. Military wrap

Objective 9

a. Flattened square bend
b. Square bend
c. Special shape bend
d. Round bend
e. Semi-round bend

Objective 10

a. Corner radius
b. Width
c. Thread length
d. Center radius
e. U-bolt length

Objective 11

a. Stamped
b. 1) Extended
   2) Diameter

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 4.

☐ 4. **Do** Job Sheet 1, "Inspect Front Suspension Components."

☐ 5. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 6. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Steps 3 and 4.

☐ 6. **Study** Information Sheet, Objectives 5 through 11.

☐ 7. **Do** Job Sheet 2, "Remove and Replace Front Spring Suspension Components."

☐ 8. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 9. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Steps 6 and 7.

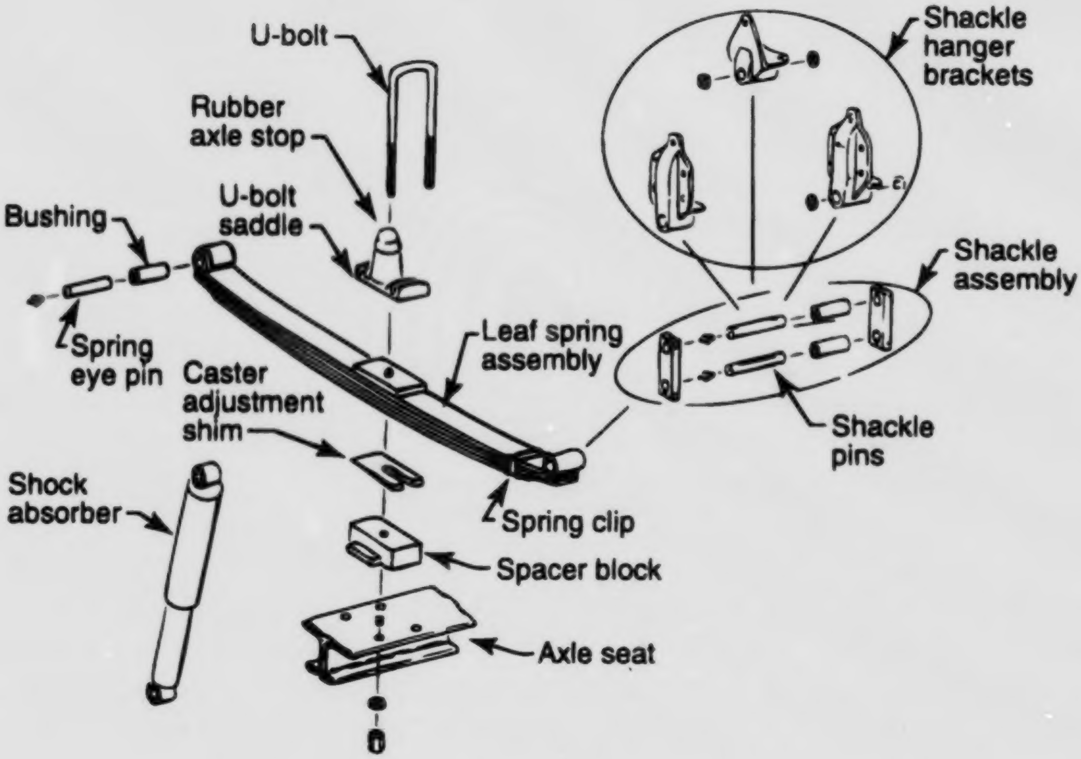
☐ 9. **Check** With instructor for any additional assignments to be completed.

☐ 10. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 11. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

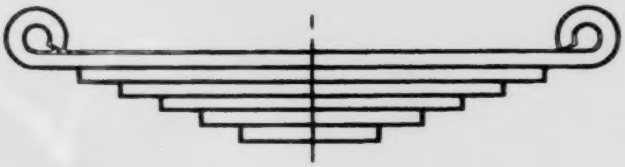
Front Suspension Components



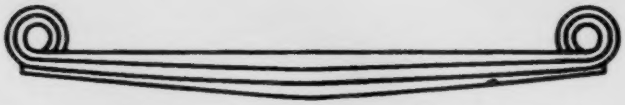
U-bolt
Shackle hanger brackets
Rubber axle stop
U-bolt saddle
Bushing
Shackle assembly
Spring eye pin
Leaf spring assembly
Caster adjustment shim
Shackle pins
Shock absorber
Spring clip
Spacer block
Axle seat

Courtesy of Dayton Parts Inc.

Basic Designs of Springs



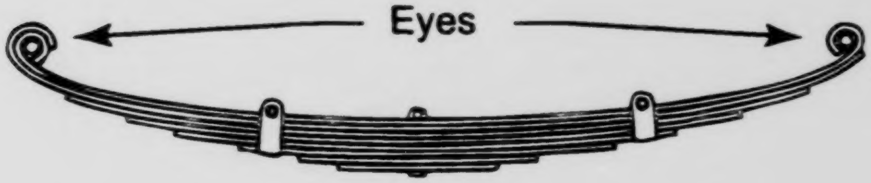
Stepped Spring



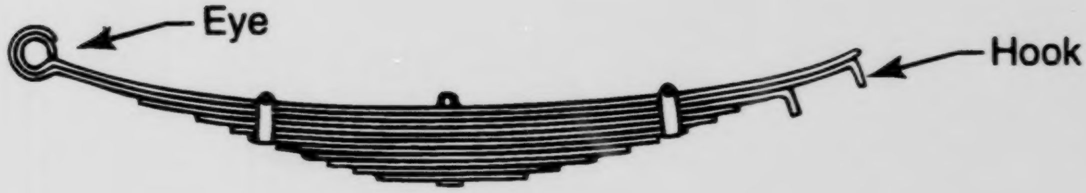
Tapered Leaf Spring

Courtesy of Peterbilt Motors Company/PACCAR Inc.

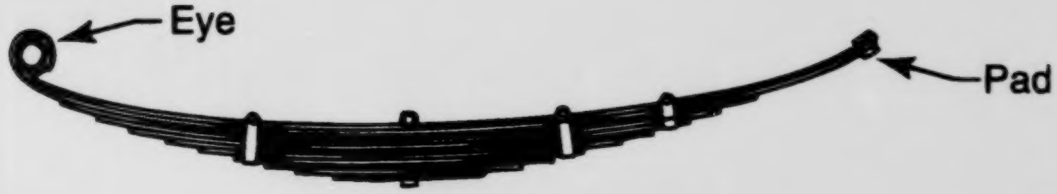
Types of Spring Assembly Ends



Eyes on Both Ends



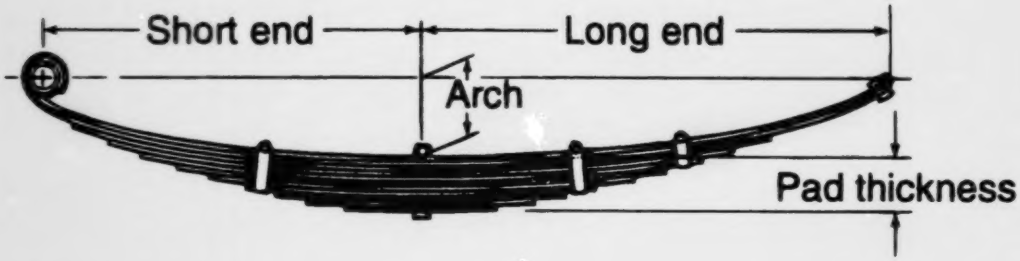
Eye and Hook



Eye and Pad

Courtesy of Dayton Parts Inc.

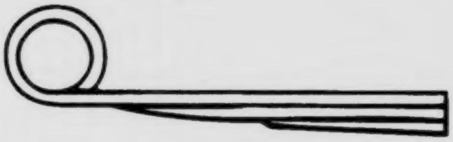
Dimensions of Spring Assemblies


Short end
Long end
Arch
Pad thickness

Courtesy of Dayton Parts Inc.

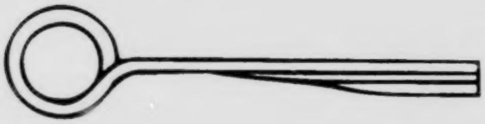
TM 4

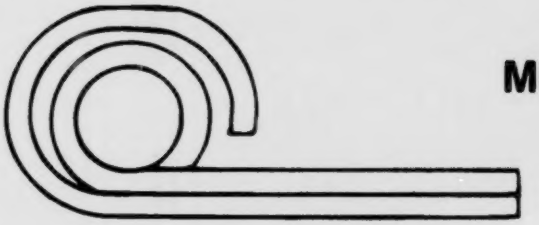
Types of Spring Eyes



Upturned Eye

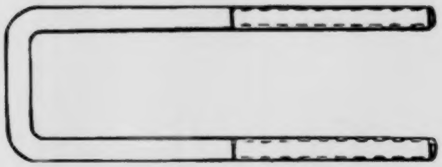
Berlin Eye



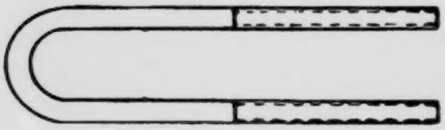


Military Wrap

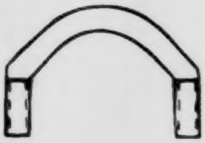
Shapes of U-Bolts



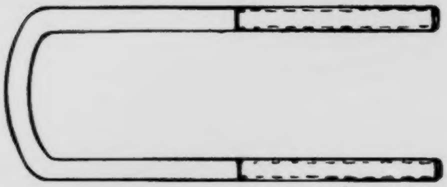
Square Bend



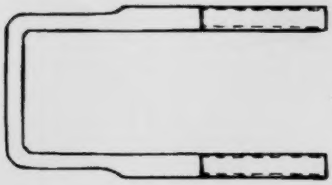
Semi-Round Bend



Special Shape Bend



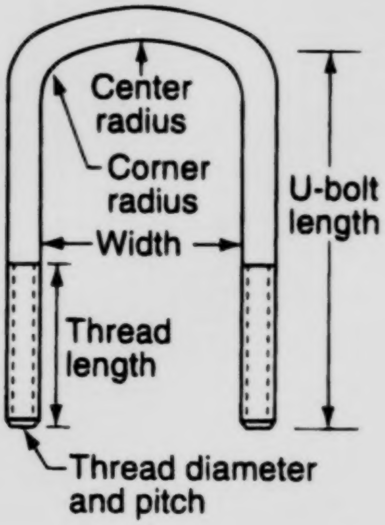
Round Bend

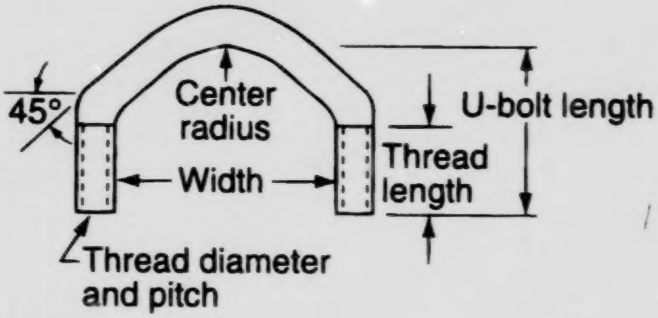


Flattened Square Bend

Courtesy of BATCO

Dimensions of U-Bolts


Center radius
Corner radius
U-bolt length
Width
Thread length
Thread diameter and pitch


45°
Center radius
U-bolt length
Width
Thread length
Thread diameter and pitch

Courtesy of BATCO

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 2C-3

Written Test 2C-7

Answers to Written Test 2C-13

Learning Activities Sheet 2C-15

Transparency Masters

1—Types of Springs 2C-17
2—Types of Springs (Continued) 2C-19
3—Rear Spring Suspension Components 2C-21
4—Types of Rear Spring Assembly Ends 2C-23
5—Types of Rear Spring Assembly Ends (Continued) 2C-25

Student Components

Student Page

Objective Sheet 2C-3

Information Sheet 2C-5

Job Sheets

1—Inspect Rear Spring Suspension Components 2C-15
2—Replace Rear Spring Suspension Components 2C-19

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Have students identify the basic components of rear spring suspensions using vehicles available in the shop. Have them describe each component's function in the overall system operation.
- Show students the types of wear that occur on rear spring suspension components. Discuss the causes of the wear and what can be done to remedy the problems.
- Discuss the different types of springs (constant rate, progressive rate, and auxiliary) and point out the advantages and disadvantages of each type.
- Show examples of rear spring assembly ends. Point out the differences between torque leaves and torque rods. If not all types are available in the shop, use sales brochures or service manuals for illustrations.
- Have students practice measuring the required dimensions on spring assemblies. Then provide parts catalogs so they can locate the appropriate spring assemblies for replacements.
- Remind students about the safety rules for working on suspensions.
- Make sure the appropriate tools, equipment, and service manuals are available for students to use in the job sheets.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *BATCO Suspension Manual (#107).* Dallas: Brake, Axle, and Tandem Company (BATCO).
- *Dayton Parts Catalog (#2—Suspension Components).* Harrisburg, PA: Dayton Parts Inc.
- *Hendrickson Technical Publication HFS-360/400, #17730-211.* Woodridge, IL: Hendrickson Truck Suspension Systems/A Boler Company.
- *International Harvester Service Manuals, CTS-2314 and CTS-2680S.* Chicago: Navistar International Transportation Corp.
- Norman, Ian Andrew, et al. *Heavy-Duty Truck Systems*, 2nd ed. Albany, NY: Delmar Publishers, 1996.

- Schultz, Erich J. *Diesel Equipment I and II.* New York: McGraw-Hill Book Company, 1982.

Suggested Supplemental Resources

Electronic Media

- *RS Series* videotape (VSS-64) or slides (SS-64)
- *RT/RTE, RURUE, U/UE Series* videotape (VSS-70) or slides (SS-70)
- *Beams, Bushings, Torque Rods, Components* videotape (VSS-190) or slides (SS-190)
- *E4 Series* videotape (VSS-195) or slides (SS-195)

The above are available from:

Hendrickson Truck Suspension Systems
300 Riverview Dr.
Benton Harbor, MI 49022-9971
1-800-973-0360 or 616-925-2122

- *Mack Suspension and Alignment Part 1 Kit* (14-399K)—Includes video and five guidebooks
- *Mack Suspension and Alignment Part 2 Kit* (14-398K)—Includes video and five guidebooks

The above are available from your local Mack Truck service center or contact:

Mack Trucks, Inc.
2100 Mack Blvd.
P.O. Box M
Allentown, PA 18105-5000
610-439-3011

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms with their definitions.

1. Axle alignment
2. Axle spacing
3. Drive line angularity
4. Equalizer
5. Load rating
6. Slipper
7. Spring rate
8. Sprung weight
9. Torque leaf
10. Torque rod
11. Unsprung weight

_____ a. Device used on the ends of leaf springs which allows the spring to slide freely in the hanger

_____ b. Device that distributes a force or weight evenly or uniformly

_____ c. Separate suspension component that transfers braking and driving forces to the frame and maintains drive line angularity

_____ d. Weight of the vehicle that is supported by the springs

_____ e. Center-to-center (CC) distance between the rear axles on a tandem suspension

_____ f. Part of some spring assemblies that acts as a torque rod

_____ g. Grade classification of a material according to how much force or weight it can carry

_____ h. Adjustments made in the relationship between the axles, steering and suspension components, and tires to bring them into correct positions

_____ i. Angles between drive/suspension components and the frame

_____ j. Weight that is not supported by the springs; includes the axle, tires, rims, brakes, and some of the steering components

Objective 2

State three purposes of rear suspension.

a. ______________________________

b. ______________________________

c. ______________________________

Written Test

Objective 3

Distinguish among types of springs by placing the following letters next to the correct descriptions:

C — Constant rate spring
V — Vari-rate spring
A — Auxiliary spring

_____ a. Sometimes known as helper or overload spring

_____ b. May be used in both front and rear axle applications

_____ c. Provides a soft, easy riding spring rate when the vehicle is empty, while also providing enough spring rate when fully loaded to function without sagging

_____ d. Used to increase spring rate when vehicle is loaded

_____ e. Usually mounted on top of the main spring assembly

_____ f. Spring deflects at a constant rate as load is added.

_____ g. Spring deflects at a slower rate as load is added.

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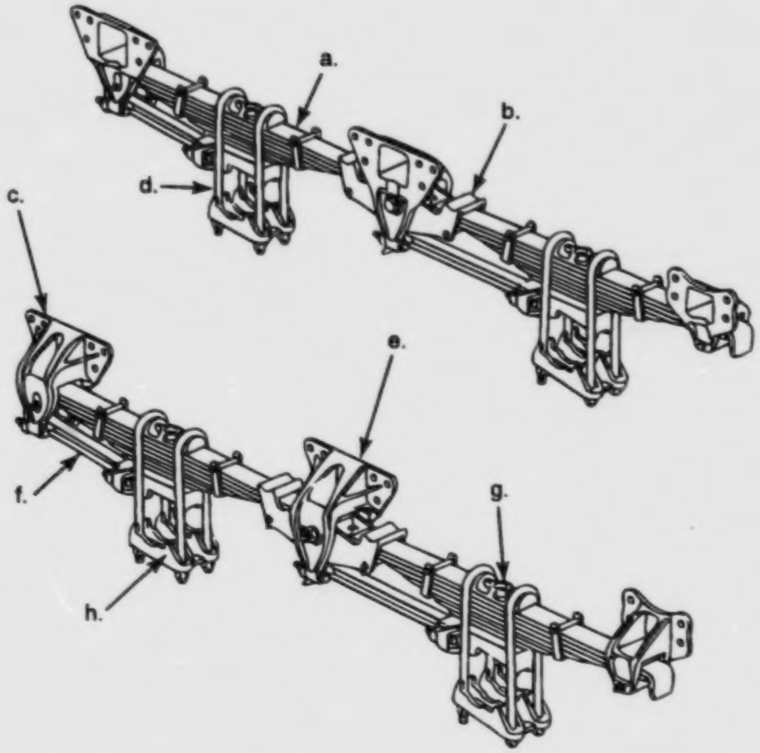
Objective 4

Identify rear spring suspension components. Write your answers in the blanks provided.



Courtesy of Hendrickson Truck Suspension Systems

a.	____________________	e.	____________________
b.	____________________	f.	____________________
c.	____________________	g.	____________________
d.	____________________	h.	____________________

Written Test

Objective 5

Match rear spring suspension components with their functions.

1. Alignment shim(s)
2. Axle seat
3. Bottom plate
4. Center hanger bracket
5. Equalizer
6. Equalizer bushing or bearing
7. Front hanger bracket
8. Rear hanger bracket
9. Spring assembly
10. Top plate
11. Torque rod bushing
12. Torque leaf
13. Torque rod
14. U-bolts

_____ a. Oscillates inside the center hanger bracket

_____ b. Reduces friction and prevents wear between torque rod and hanger brackets and between torque rod and axle seat

_____ c. Attaches the front of the forward spring assembly to the frame

_____ d. Used with slipper type springs to transfer braking and driving forces from the axle to the frame

_____ e. Located between the axle and the bottom of the spring assembly

_____ f. Attaches the rear of the forward spring and the front of the rear spring to the frame

_____ g. Hold the spring assembly to the axle seat

_____ h. Used in spring suspensions in place of torque rods

_____ i. Located underneath the axle

_____ j. Attaches the rear of the rear spring to the frame

_____ k. Contains a groove for each u-bolt

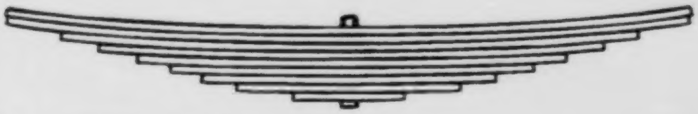
_____ l. Reduces friction and prevents wear between the equalizer and the pivot shaft

_____ m. Absorbs, stores, and then releases energy as the vehicle passes over bumps

_____ n. Changes the effective length of the torque rod to provide a means to align the rear axle to the frame

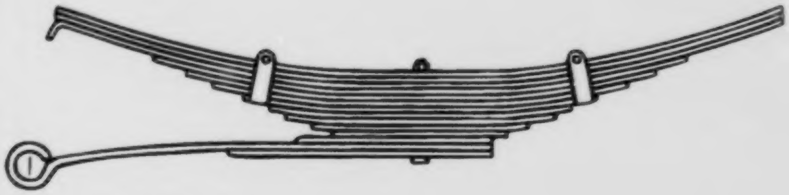
Objective 6

Identify the following types of rear spring assembly ends. Write your answers in the blanks provided.



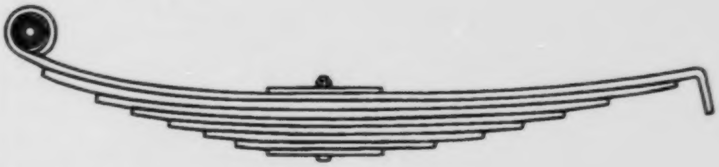
Courtesy of Dayton Parts Inc.

a. ____________________



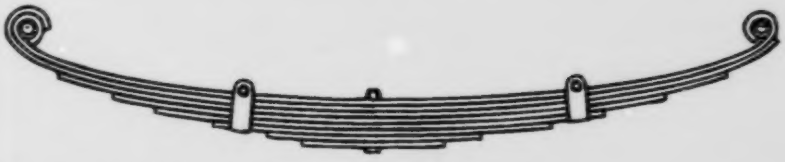
Courtesy of Dayton Parts Inc.

b. ____________________



Courtesy of Dayton Parts Inc.

c. ____________________



Courtesy of Dayton Parts Inc.

d. ____________________

Objective 7

List four dimensions required for ordering spring assemblies.

a. ____

b. ____

c. ____

d. ____

Written Test

Objective 8

Select true statements concerning load rating of spring assemblies by placing a "T" next to true statements and an "F" next to false statements.

_____ a. This is a function of length, width, number of leaves, and type of steel.

_____ b. Load rating is often stamped on new springs.

_____ c. May be rated by the manufacturer at the axle (unsprung weight) or at the ground (sprung plus unsprung)

_____ d. Common capacities range from 1,000 to 20,000 lbs.

Objective 9

Complete statements concerning failure of spring assemblies by circling the correct answers.

a. All springs will eventually fail from (**fatigue, wear**) due to repeated flexing.

b. Factors that affect spring life include:

1) Load factor—The greater the load, the (**shorter, longer**) the life of the spring.

2) Shock absorbers—Since shock absorbers slow the rate of jounce and rebound, the spring is deflected (**more, less**) every time the vehicle hits a bump. Therefore, they will last longer.

3) Corrosion—Proper paints and care will (**slow, speed**) the spread of corrosion.

4) Maintenance—U-bolts must be (**replaced, retorqued**) after initial installation and at specified service intervals in order for springs to last as long as possible.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a.	6	f.	9
b.	4	g.	5
c.	10	h.	1
d.	8	i.	3
e.	2	j.	11

Objective 2

Answers should include any three of the following:

a. To support the weight of the vehicle and its load
b. To cushion the frame and cab of the vehicle from road shocks
c. To transfer braking forces and driving forces from the axle to the frame
d. To maintain axle alignment
e. To maintain drive line angularity

Objective 3

a.	A	e.	A
b.	C	f.	C
c.	V	g.	V
d.	A		

Objective 4

a. Spring assembly
b. Equalizer
c. Front hanger brackets
d. U-bolt
e. Center hanger brackets
f. Torque rod
g. Top plate
h. Bottom plate

Objective 5

a.	5	e.	2	i.	3	m.	9
b.	11	f.	4	j.	8	n.	1
c.	7	g.	14	k.	10		
d.	13	h.	12	l.	6		

Objective 6

a. Slipper type
b. Slipper with torque leaf
c. Eye and slipper
d. Eyes on both ends

Answers to Written Test

Objective 7

Answers should include any four of the following:

a. Axle spacing
b. Spring width
c. Number of leaves
d. Length of long end
e. Length of short end
f. Thickness of pad
g. Arch

Objective 8

a. T
b. F
c. T
d. F

Objective 9

a. Fatigue
b. 1) Shorter
   2) Less
   3) Slow
   4) Retorqued

Unit 2-C Rear Spring Suspension

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 9.

Optional

☐ 4. **View** Videotape entitled "Beams, Bushings, Torque Rods, Components."

☐ 5. **Do** Job Sheet 1, "Inspect Rear Spring Suspension Components."

☐ 6. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 7. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Steps 3 and 5.

☐ 7. **Do** Job Sheet 2, "Replace Rear Spring Suspension Components."

☐ 8. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 9. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 7.

☐ 9. **Check** With instructor for any additional assignments to be completed.

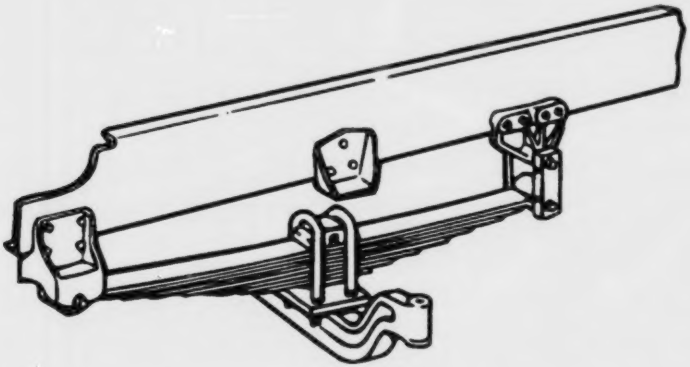
☐ 10. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 11. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

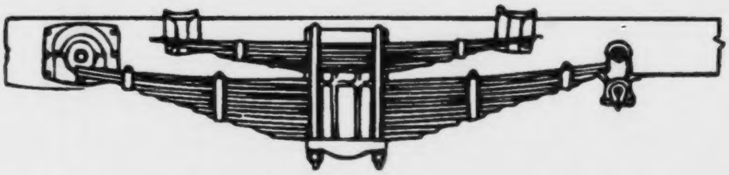
***Permission to duplicate this form is granted.**

Types of Springs

Constant Rate Springs



Front Axle Application

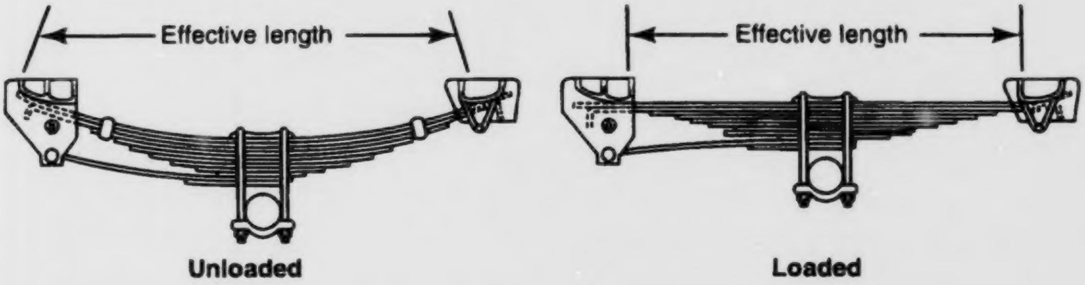


Rear Axle Application

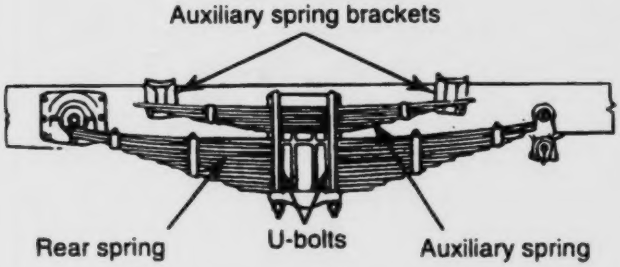
Courtesy of Navistar International Transportation Corp.

TM 1

Types of Springs
(Continued)


Effective length
Effective length
Unloaded
Loaded

Vari-Rate Spring

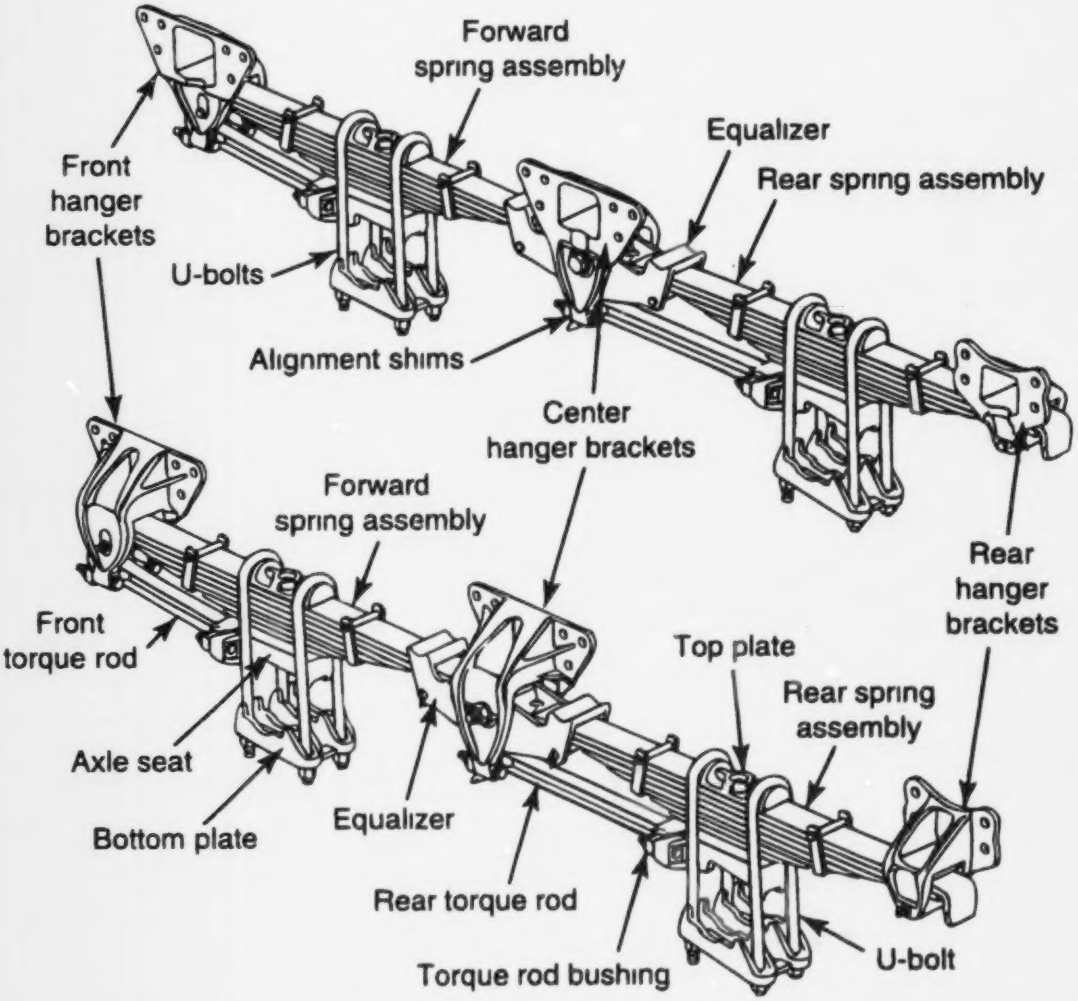

Auxiliary spring brackets
Rear spring
U-bolts
Auxiliary spring

Auxiliary Spring

Courtesy of Navistar International Transportation Corp.

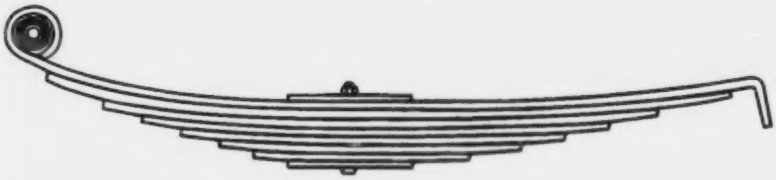
TM 2

Rear Spring Suspension Components

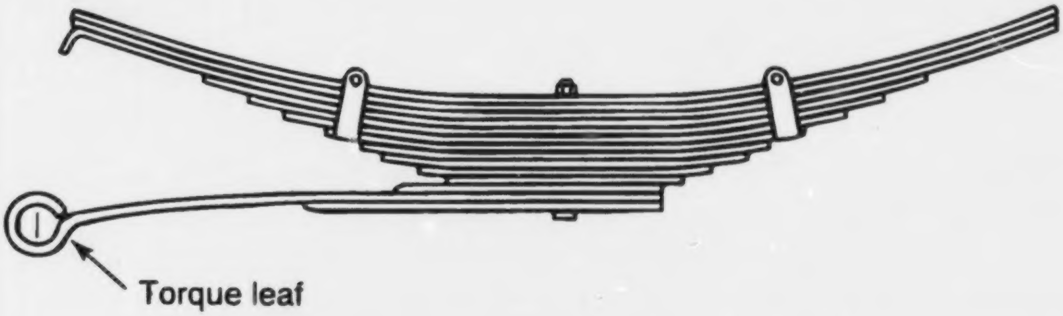

Forward spring assembly
Equalizer
Rear spring assembly
Front hanger brackets
U-bolts
Alignment shims
Center hanger brackets
Forward spring assembly
Rear hanger brackets
Front torque rod
Top plate
Rear spring assembly
Axle seat
Bottom plate
Equalizer
Rear torque rod
Torque rod bushing
U-bolt

Courtesy of Hendrickson Truck Suspension Systems

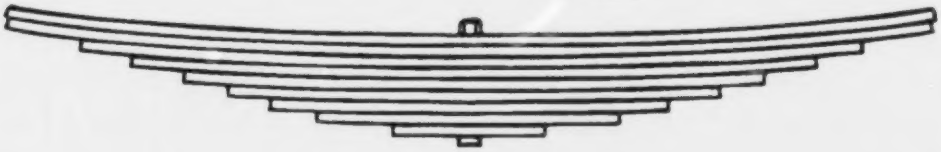
Types of Rear Spring Assembly Ends



Eye and Slipper



Slipper with Torque Leaf

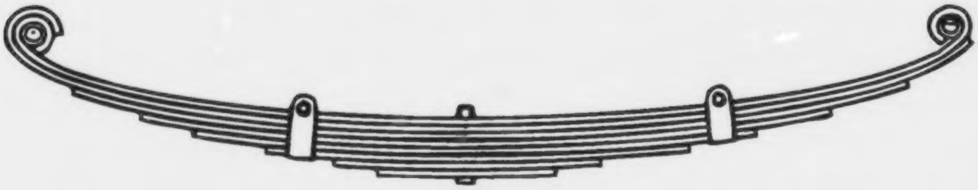


Slipper Type

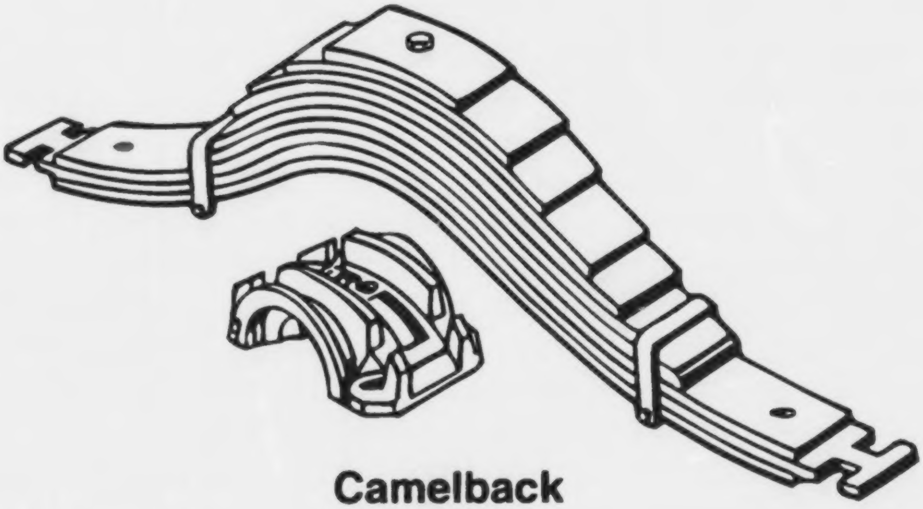
Courtesy of Dayton Parts Inc.

Types of Rear Spring Assembly Ends

(Continued)



Eyes on Both Ends



Camelback

Courtesy of Dayton Parts Inc.

TM 5

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 3C–3

Written Test 3C–7

Answers to Written Test 3C–13

Learning Activities Sheet 3C–15

Transparency Masters

1—Leaf Spring Suspended Beams 3C–17
2—Leaf Spring Suspended Beams (Continued) 3C–19
3—Rubber Cushioned Beams 3C–21
4—Rubber Cushioned Beams (Continued) 3C–23
5—Basic Beam Components 3C–25

Student Components

Student Page

Objective Sheet 3C–3

Information Sheet 3C–5

Job Sheet

1—Inspect Rear Beam Suspension Components 3C–17

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Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheet. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of this activity and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Have students identify the basic components of rear beam suspensions using vehicles available in the shop. Have them describe each component's function in the overall system operation.

- Show examples of as many models of rear beam suspensions as possible. Use illustrations in manufacturer's sales brochures or technical publications if needed. Students need to see the two basic types—leaf spring and rubber cushioned. Provide updated information on new models and other manufacturers as they become available.

- Discuss the basic differences between the various models of rear beam suspensions. Point out the most common ones that students might work on.

- Discuss the basic operation of the various rear beam suspension models. Use mock-ups and actual components if possible.

- Remind students about the safety rules for working on suspensions.

- Make sure the appropriate tools, equipment, and service manuals are available for students to use in the job sheet.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the job sheet. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Suggested Activities

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *BATCO Suspension Manual (#107).* Dallas: Brake, Axle, and Tandem Company (BATCO).
- *Hendrickson Technical Publications #17730-68, 070, 107, 168, and 190.* Woodridge, IL: Hendrickson Truck Suspension Systems/A Boler Company.
- Norman, Ian Andrew, et al. *Heavy-Duty Truck Systems*, 2nd ed. Albany, NY: Delmar Publishers, 1996.
- Schultz, Erich J. *Diesel Equipment I and II.* New York: McGraw-Hill Book Company, 1982.

Written Test

Name ______________________________

Date ______________________________ Score __________

Objective 1

Match the terms with their definitions.

1. Center bushing	4. End bushing	7. Rebound
2. Cross tube	5. Equalizing beam	8. Torque rod
3. Durometer	6. Jounce	

_____ a. Suspension component that transfers braking and driving forces to the frame and maintains drive line angularity

_____ b. Forged steel or aluminum suspension component mounted to the underside of the axles; distributes weight equally between both axles

_____ c. Suspension component that restricts side movement of the axles during cornering

_____ d. Downward movement of the axle as the wheels return to the road

_____ e. Type of bushing that connects the beam ends to the axles

_____ f. Type of bushing that provides a pivot point for the beams and connects beams to the upper portion of the suspension

_____ g. Upward movement of the axle as the wheels go over a bump

_____ h. Instrument that measures the hardness (stiffness) of a material such as rubber or urethane; the higher the number, the harder the material

Objective 2

State four purposes of rear beam suspension.

a. ______________________________

b. ______________________________

c. ______________________________

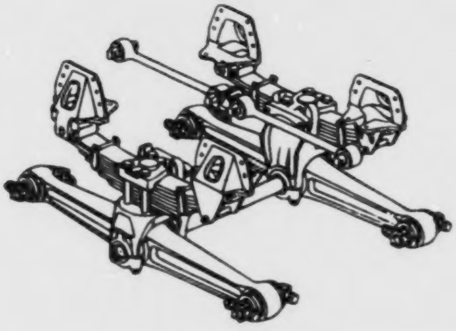
d. ______________________________

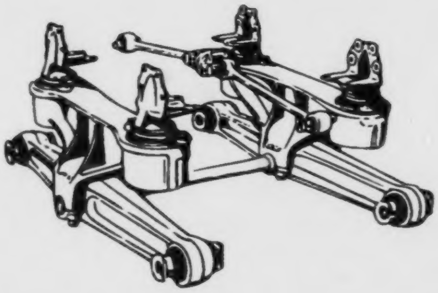
Written Test

Objective 3

Distinguish among the basic models of rear beam suspensions by placing the following letters in the blanks provided.

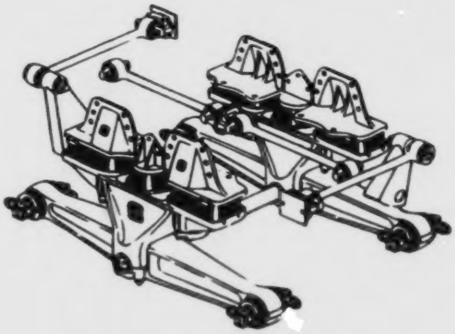
LS — Leaf spring suspended beams
R —Rubber cushioned beams

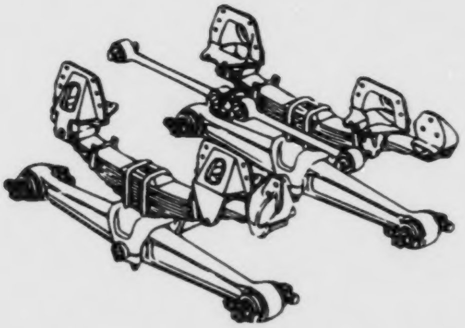




Courtesy of Hendrickson Truck Suspension Systems

a. ____________________ b. ____________________



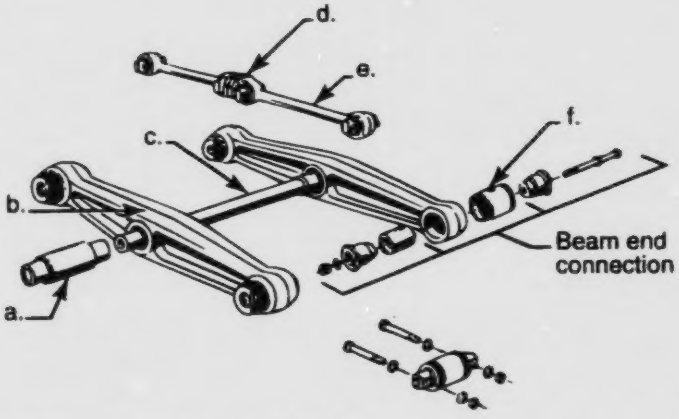


Courtesy of Hendrickson Truck Suspension Systems

c. ____________________ d. ____________________

Objective 4

Identify the basic beam components of rear beam suspensions. Write your answers in the blanks provided.



Courtesy of Hendrickson Truck Suspension Systems

a. ______________________ d. ______________________

b. ______________________ e. ______________________

c. ______________________ f. ______________________

Objective 5

Match the basic concepts of rear beam suspensions with their correct functions.

- **RT2/RTE2 and U2/UE2 series**

1. Extended leaf bracket (#3)
2. Front hanger bracket (#1)
3. Rear hanger bracket (#2)
4. Saddle
5. Spring assembly

_____ a. Attaches the front of the spring to the frame with a spring eye pin/bushing combination; draw keys or bolts secure the pin to the bracket

_____ b. Cushions the vehicle from road shocks; eye and slipper end designs

_____ c. Used on RTE or UE models only; cam-shaped; contacts the top four extended leaves

_____ d. Attaches the rear of the spring to the frame; "slipper type" allowing the spring to slide as it flexes; the spring is loosely retained by a roller and bolt

- **RS series**

1. Frame hanger
2. Overload cushion
3. Rubber load cushions
4. Saddle
5. Saddle bushings

_____ a. Used to provide a flexible connection between the saddle and the frame hangers

_____ b. Used to absorb road shocks; available in 40, 60, and 70 durometer for different applications (on or off-highway)

_____ c. Bolted to the frame rails to attach the load cushion to the frame; stud passes through the saddle bushings and holds the saddle to the frame

_____ d. Contacts the overload frame hanger after the load cushions are partially compressed; provides for a variable spring rate

- **SR series**

1. Frame hanger
2. Saddle
3. Shear springs

_____ a. Used to absorb road shocks

_____ b. Attaches the suspension to the frame

_____ c. Forms the lower mounting surface for the shear springs; legs clamp around the center bushing of the equalizing beams

- **V4 series**

1. Axle stop bracket
2. Elastic module
3. Rebound stop
4. Rebound stop hanger

_____ a. Prevents excessive rebound travel which would put a damaging tension load on the elastic modules

_____ b. Used to absorb road shocks and provide a shock absorber effect; each unit (module) contains an internal jounce stop to prevent excessive compression of the module

_____ c. Prevents excessive oscillation of the equalizing beams which could hit the underside of the module and damage it

_____ d. Mounts the rebound stop to the frame

- **HN series**

1. Diagonally mounted rubber pads
2. Rubber bolster spring

_____ a. Cushions the vehicle from road shocks; provides for a variable spring rate

_____ b. Used to absorb road shocks

Objective 6

Complete statements concerning the operation of rear beam suspension models and components by circling the correct answers.

a. Equalizing beams and torque rods work in a (**hexagon, parallelogram**) style linkage to maintain the pinion angle (drive line angularity) of the axles.

b. Center bushings and end bushings permit the axles some self aligning capability during (**cornering, braking**).

c. Extended leaf spring models

   1) When the vehicle is unloaded, the top four extended leaves contact the third spring hanger. This creates a gap between the spring and the #2 hanger. The effect is a (**low, high**) spring rate which gives the vehicle a good ride.

   2) When the vehicle is loaded, the extended leaves flex until the spring contacts the #2 bracket. The shorter effective length (**lowers, raises**) the spring rate so the suspension can carry a heavy load.

d. SR series—Rubber shear springs provide a two stage, (**constant rate, variable rate**) suspension.

e. V4 series

   1) The bonded rubber portion of the load module assembly helps to carry some of the load. The outer chamber contains a liquid which will be forced into the inner chamber as the vehicle is loaded. As more liquid enters the inner chamber, the air inside the bladder is (**compressed, expanded**).

   2) A (**leveling, dampener**) valve controls the flow of liquid to and from the outer chamber and the inner chamber.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 8
b. 5
c. 2
d. 7
e. 4
f. 1
g. 6
h. 3

Objective 2

Any four of the following:

a. To support the weight of the vehicle and its load
b. To cushion the frame and cab of the vehicle from road shocks
c. To transfer braking forces and driving forces from the axle to the frame
d. To allow axles some self alignment during cornering
e. To maintain axle alignment
f. To maintain drive line angularity

Objective 3

a. LS
b. R
c. R
d. LS

Objective 4

a. Center bushing
b. Equalizing beam
c. Cross tube
d. Torque rod cross member bracket
e. Torque rod
f. End bushing

Objective 5

- RT2/RTE2 and U2/UE2 series

a. 2
b. 5
c. 1
d. 3

- RS series

a. 5
b. 3
c. 1
d. 2

- SR series

a. 3
b. 1
c. 2

- V4 series

a. 3
b. 2
c. 1
d. 4

- HN series

a. 2
b. 1

Objective 6

a. Parallelogram
b. Cornering
c. 1) Low
   2) Raises
d. Variable rate
e. 1) Compressed
   2) Dampener

Prerequisites:
None

Learning Activities Sheet

Student Name ____________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 6.

☐ 4. **Do** Job Sheet 1, "Inspect Rear Beam Suspension Components."

☐ 5. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 6. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Steps 3 and 4.

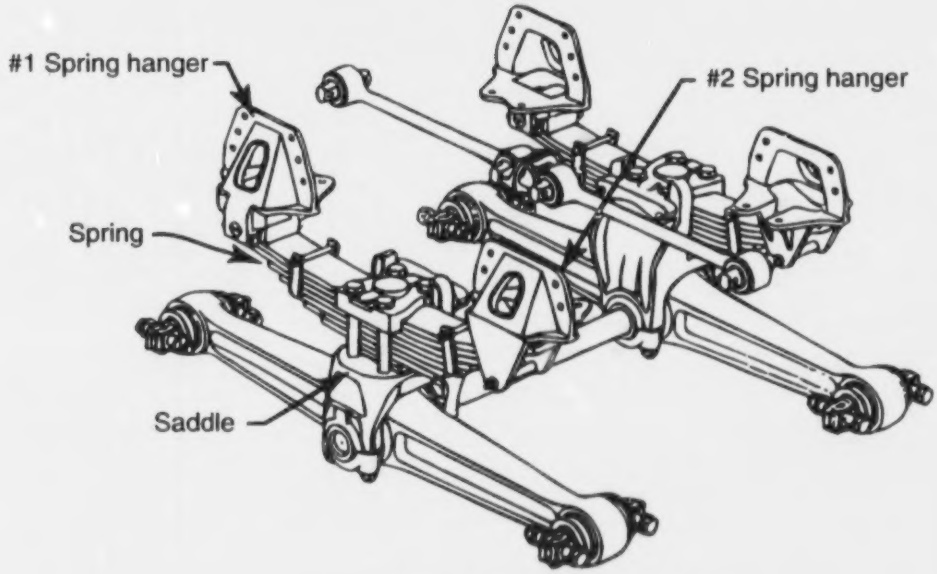
☐ 6. **Check** With instructor for any additional assignments to be completed.

☐ 7. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

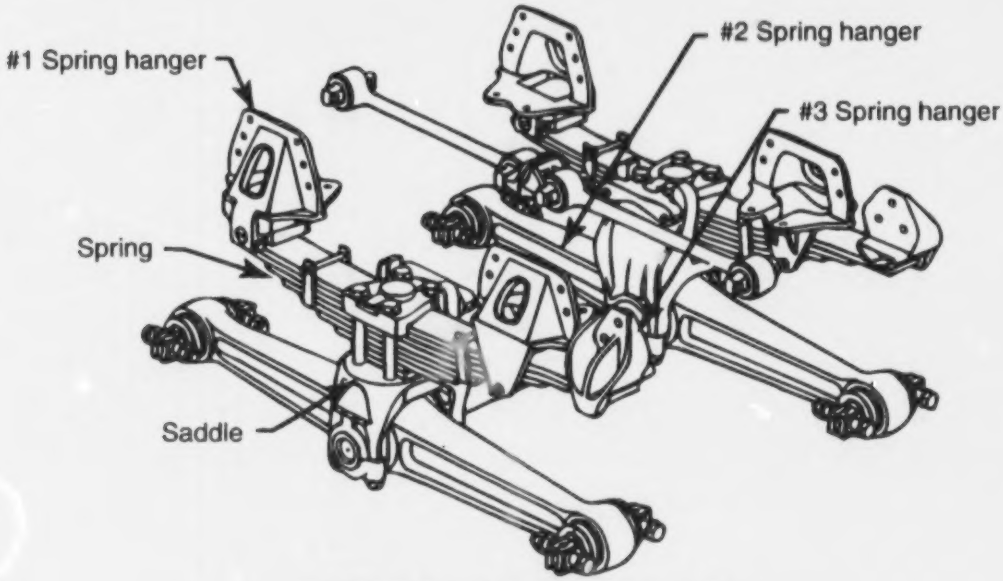
☐ 8. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Leaf Spring Suspended Beams


#1 Spring hanger
#2 Spring hanger
Spring
Saddle

RT2 Series Suspension

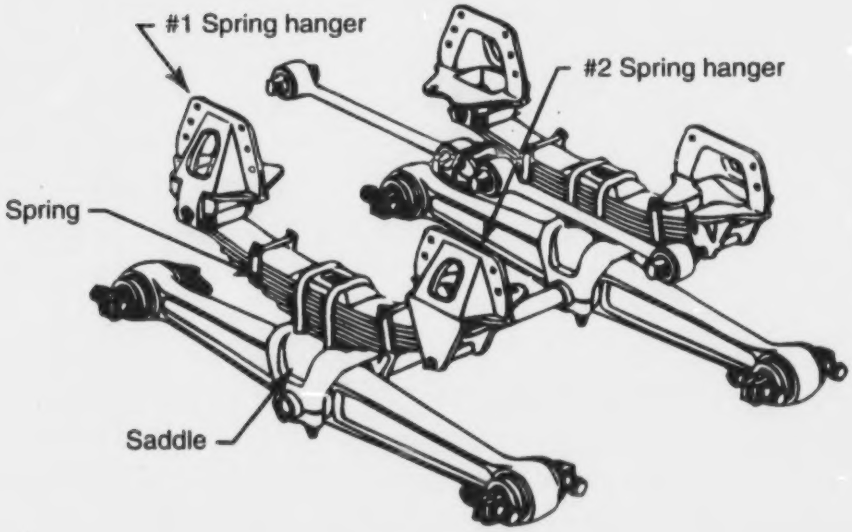

#1 Spring hanger
#2 Spring hanger
#3 Spring hanger
Spring
Saddle

RTE2 Series Suspension

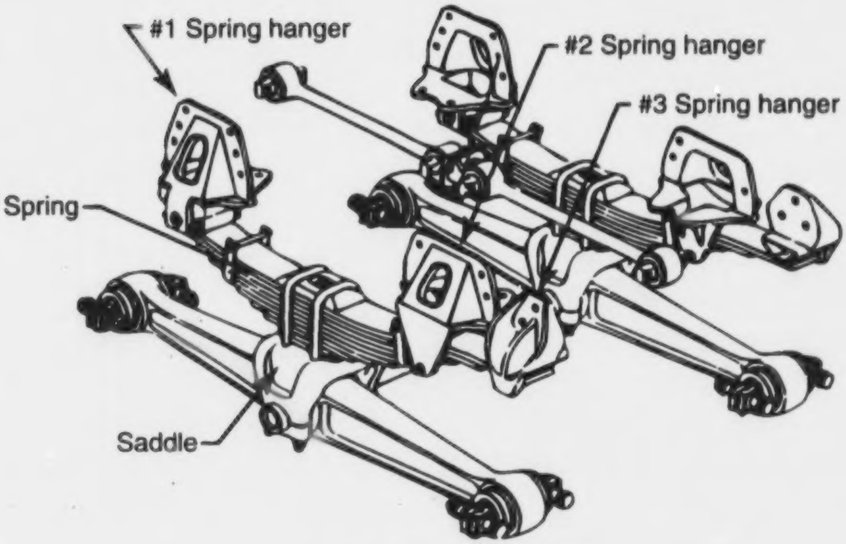
Courtesy of Hendrickson Truck Suspension Systems

TM 1

Leaf Spring Suspended Beams
(Continued)


#1 Spring hanger
#2 Spring hanger
Spring
Saddle

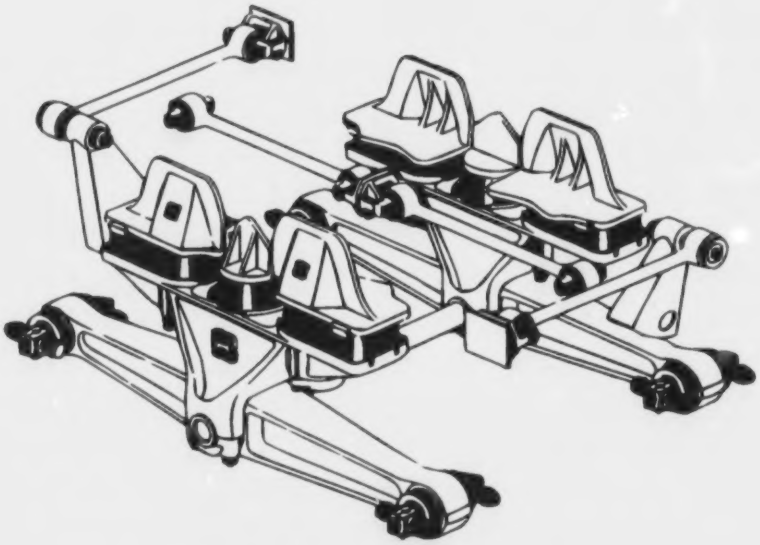
U2 Suspension


#1 Spring hanger
#2 Spring hanger
#3 Spring hanger
Spring
Saddle

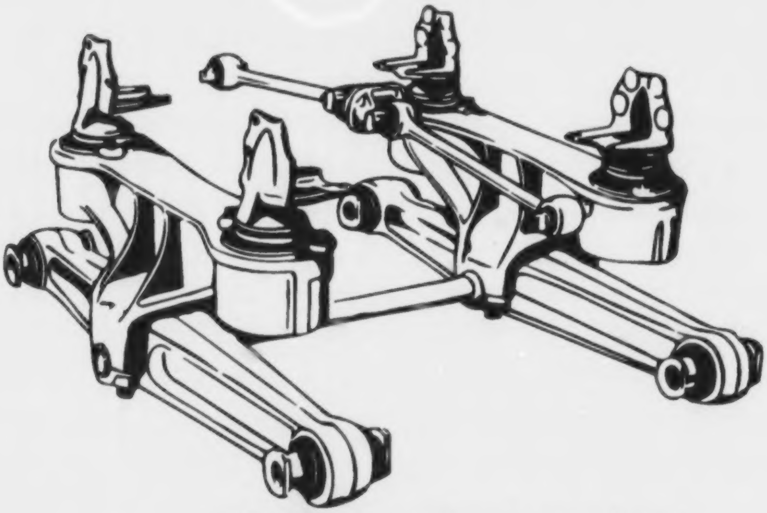
UE2 Suspension

Courtesy of Hendrickson Truck Suspension Systems

Rubber Cushioned Beams



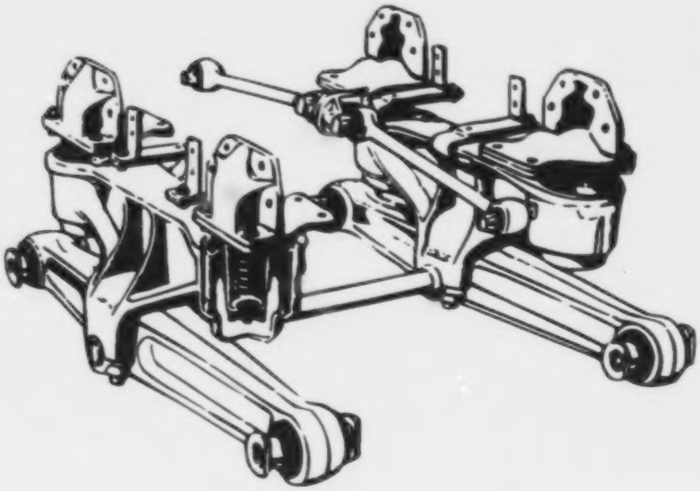
RS Series Suspension



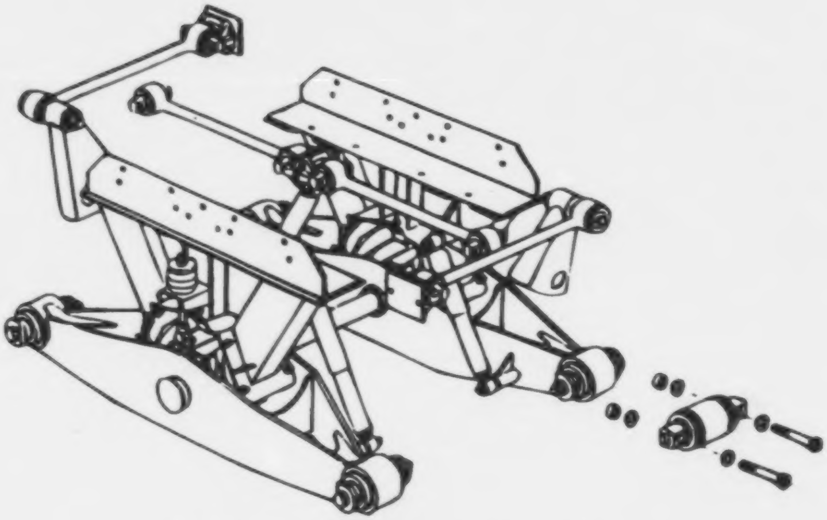
SR Series Suspension

Courtesy of Hendrickson Truck Suspension Systems

Rubber Cushioned Beams
(Continued)



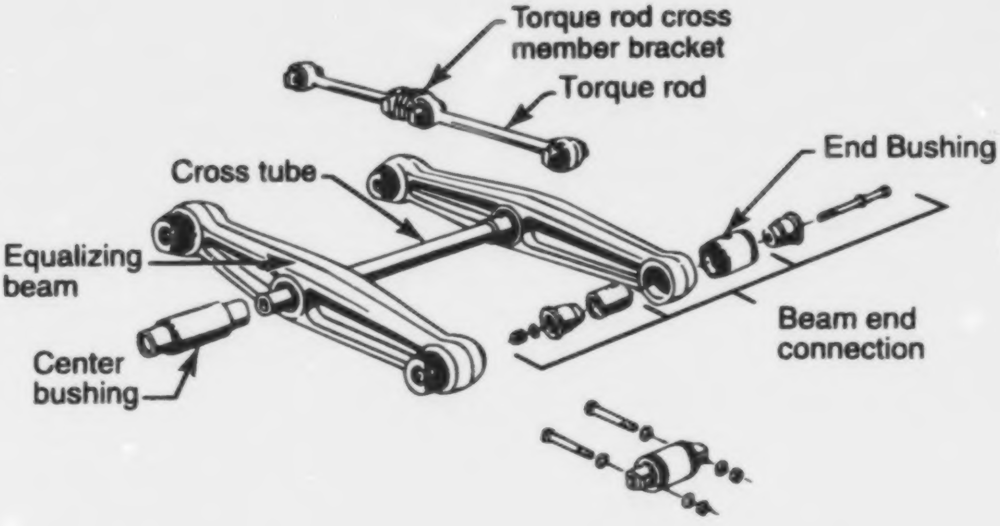
V4 Series Suspension



HN Series Suspension

Courtesy of Hendrickson Truck Suspension Systems

Basic Beam Components


Torque rod cross member bracket
Torque rod
End Bushing
Cross tube
Equalizing beam
Beam end connection
Center bushing

Courtesy of Hendrickson Truck Suspension Systems

Unit 4-C Rear Air Suspension

Unit Contents

Teacher Components

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Transparency Masters

1—Air Suspension Components 4C-17
2—Types of Air Springs 4C-19
3—Parts of an Air Spring 4C-21
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Student Components

Student Page

Objective Sheet 4C-3

Information Sheet 4C-5

Job Sheets

1—Inspect, Test, and Replace an Air Spring 4C-15
2—Inspect and Test an Air Suspension System, Replace the Leveling Valve, and Adjust Frame (Ride) Height 4C-19

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Have students identify the basic components of rear air suspensions using vehicles available in the shop. Have them describe each component's function in the overall system operation.

- Show examples of the basic types of air springs (rolling lobe or convoluted).

- Construct a cutaway of an air spring so that students can identify both the external and internal parts. Make sure students understand all of the mounting studs and air fittings on the upper retainer plate.

- Have students practice identifying and measuring air springs. Then provide parts catalogs so they can locate the appropriate air springs for replacements.

- On an actual vehicle, have students locate the basic valves used on rear air suspensions. Also have them identify the three air ports on the leveling valve. You may want to disconnect the lines from all the air ports and then have students reconnect them to test their basic understanding of the ports. Allow time for students to practice operating the basic valves or construct a mock-up of the air system so students can see how they operate.

- Show students examples of air spring failures. Discuss the causes of the failures and what can be done to prevent or remedy the failures.

- Remind students about the safety rules for working on suspensions.

- Make sure the appropriate tools, equipment, and service manuals are available for students to use in the job sheets.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *BATCO Suspension Manual (#107).* Dallas: Brake, Axle, and Tandem Company (BATCO).
- *Dayton Parts Catalog (#2—Suspension Components).* Harrisburg, PA: Dayton Parts Inc.
- *Euclid Parts Catalog, Volumes III and IV.* Cleveland, OH: Euclid Industries, Inc.

- *Hendrickson Technical Publication #17730-212*. Woodridge, IL: Hendrickson Truck Suspension Systems/A Boler Company.
- *Kenworth Maintenance Manual, Form 17071*. Bellevue, WA: PACCAR, Inc., 1987.
- Norman, Ian Andrew, et al. *Heavy-Duty Truck Systems*, 2nd ed. Albany, NY: Delmar Publishers, 1996.
- *Peterbilt Maintenance Manual (for Models 379, 377, 375, 357, and 355) (Catalog #5290)*. Newark, CA: Peterbilt Motors Company, 1987.
- Schultz, Erich J. *Diesel Equipment I and II*. New York: McGraw-Hill Book Company, 1982.

Suggested Supplemental Resources

Print Media

- *RS Series* videotape (VSS-64) or slides (SS-64)
- *RT/RTE, RURUE, U/UE Series* videotape (VSS-70) or slides (SS-70)
- *Beams, Bushings, Torque Rods, Components* videotape (VSS-190) or slides (SS-190)
- *E4 Series* videotape (VSS-195) or slides (SS-195)

The above are available from:

Hendrickson Truck Suspension Systems

300 Riverview Dr.

Benton Harbor, MI 49022-9971

1-800-973-0360 or 616-925-2122

- *Mack Suspension and Alignment Part 1 Kit* (14-399K)—Includes video and five guidebooks
- *Mack Suspension and Alignment Part 2 Kit* (14-398K)—Includes video and five guidebooks
- *Mack Air Suspension* service manual (#14-101)

The above are available from your local Mack Truck service center or contact:

Mack Trucks, Inc.
2100 Mack Blvd.
P.O. Box M
Allentown, PA 18105-5000
610-439-3011

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms with their definitions.

1. Air spring
2. Convolution
3. Failure analysis
4. Inversion valve
5. Leveling valve
6. Pressure protection valve
7. Rolling lobe
8. Spring rate
9. Transverse

_____ a. Amount of weight required to deflect a spring one inch

_____ b. Design that is curved or rounded into a cylinder shape

_____ c. Systematic approach for determining the cause of a system or part failure

_____ d. Type of valve that supplies air to the suspension system from the air brake reservoir

_____ e. Direction that indicates objects are located crosswise to the main lengthwise axis

_____ f. Type of valve that controls air flow into and out of the air springs to maintain a constant frame height whether loaded or empty

_____ g. Air-filled device that acts as a variable rate suspension spring

_____ h. Design that is shaped with curves and folds to the outside and then back to the center

Objective 2

State three purposes of rear air suspension.

a. ______________________________

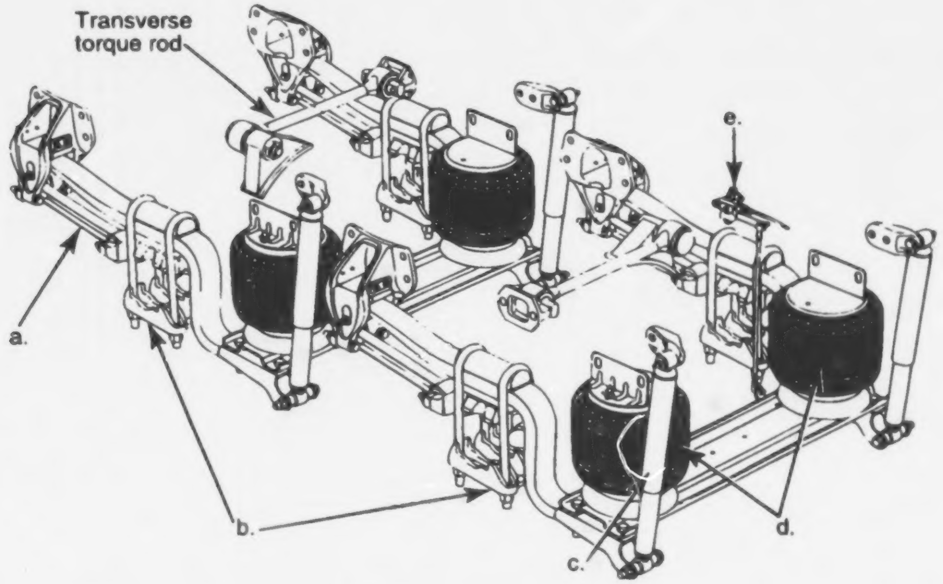
b. ______________________________

c. ______________________________

Written Test

Objective 3

Identify air suspension components. Write your answers in the blanks provided.



Courtesy of Hendrickson Truck Suspension Systems

a. ____________________ d. ____________________

b. ____________________ e. ____________________

c. ____________________

Objective 4

Match air suspension components with their functions. Functions continue on the next page.

1. Air springs
2. Inversion valve
3. Leveling valve
4. Pressure protection valve
5. Shock absorbers
6. Spring assemblies
7. Torque rods

_____ a. Used in many air suspension systems as a mounting point for the air springs

_____ b. Used to control air flow into and out of the air springs to maintain a constant frame height

_____ c. Used in air suspensions much as they are in other suspension systems—To hold the axle in alignment and to transmit braking and driving forces to the frame

_____ d. Used when hooking or unhooking a trailer so the driver does not have to lift the weight of the trailer with the trailer landing gear

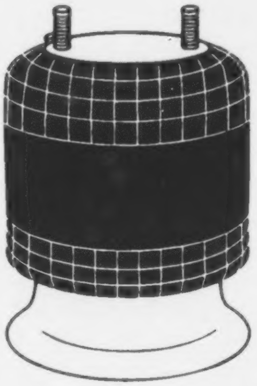
_____ e. Serve as suspension springs with infinitely variable spring rates

_____ f. Dampen the jounce/rebound oscillations which occur when the vehicle hits a bump

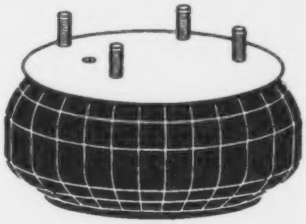
_____ g. Supplies air to the suspension system from the air brake reservoir

Objective 5

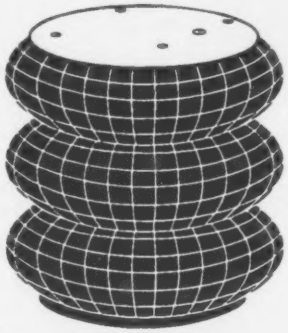
Identify the following types of springs. Write your answers in the blanks provided.



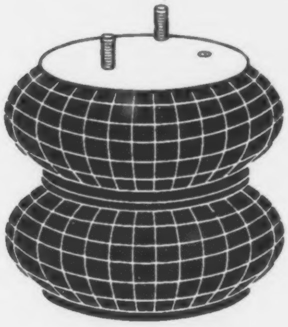
a. ______________________



b. ______________________



c. ______________________



d. ______________________

Written Test

Objective 6

Match the parts of an air spring with their correct descriptions

1. Air fitting hole
2. Combination air and mounting stud
3. Flexible member
4. Girdle ring or hoop
5. Internal rubber bumper
6. Piston
7. Standard bolt or stud
8. Tapped hole
9. Upper retainer (end) plate

_____ a. Heavy duty rubber ring located between the convolutions to help provide lateral stability to the air spring

_____ b. Provides studs or tapped holes for mounting air spring to suspension

_____ c. Used to support the weight of the vehicle if the air spring pressure is low and to prevent damage to the suspension and vehicle

_____ d. Metal plate permanently attached to the flexible member (flat plate rolls into a bead plate to hold the flexible member); contains various mounting studs and air fittings

_____ e. Port for air to flow in and out of the air spring

_____ f. Multi-layered flexible wall consisting of rubber and reinforced fabric

_____ g. Alternate means of mounting the air spring by using a bolt instead of a stud

_____ h. Used to attach the air spring unit to the suspension and frame

_____ i. Used to attach the air spring unit to the suspension and permits air flow to and from the air spring

Objective 7

Describe the procedure for identifying appropriate replacement air springs.

____

____

____

____

____

____

Objective 8

Distinguish among the basic valves used on rear air suspensions by placing the following letter next to the correct descriptions:

I — Inversion (dump) valve
L — Leveling valve
P — Pressure protection valve

_____ a. This valve is installed between the outlet port of the leveling valve and the inlet of the air springs.

_____ b. This valve is mounted to the frame while its actuating arm will be connected to the axle with a link.

_____ c. This valve will only allow air to flow to the suspension if pressure in the reservoir is above a safe minimum (usually about 65 to 70 psi).

_____ d. This valve's control port is connected to a control valve in the dash of the vehicle.

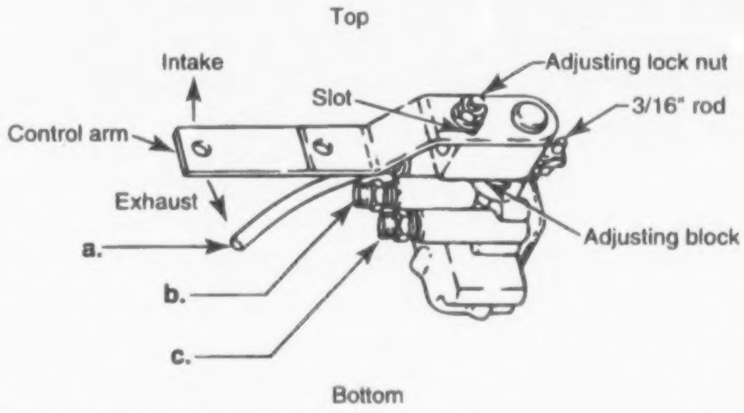
_____ e. Linkage of this valve is adjustable to provide the correct frame height.

_____ f. Suspension systems may use one of these valves for each rear axle, or one valve can control the air springs on both axles.

_____ g. In the event of a loss of pressure in the reservoir, this valve will close, thus conserving the remaining air for the brake system.

Objective 9

Identify the air ports of a leveling valve. Write your answers in the blanks provided.



Courtesy of Peterbilt Motors Company/PACCAR Inc.

a. ______________________ c. ______________________

b. ______________________

Written Test

Objective 10

Complete statements concerning common causes of air spring failures by circling the correct answers.

a. Long life or use in the field—Air springs of the proper size and design will last up to one (**thousand, million**) miles in use. However, eventually the rubber will wear in the (**bolted, flexing**) area, and the air spring will (**burst, leak**).

b. Cuts or abrasion due to interference with other suspension components—Improper installation or using springs too (**small, large**) in diameter for application

c. Torn flexible member due to (**over-extension, over-use**) of the air spring; may be caused by:

- Incorrect shock absorber
- Broken shock absorber or shock mounting bracket
- Incorrect air spring for the application

d. Driving the vehicle with (**too much, no**) air in the air springs—May cause the blind nut inside the retainer plate to quickly wear a hole in the flexible member.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 8
b. 7
c. 3
d. 6
e. 9
f. 5
g. 1
h. 2

Objective 2

Any three of the following:

a. To support the weight of the vehicle and its load
b. To cushion the frame and cab of the vehicle from road shocks
c. To transfer braking forces and driving forces from the axle to the frame
d. To maintain a constant frame height as the vehicle is located or unloaded
e. To maintain axle alignment
f. To maintain drive line angularity

Objective 3

a. Torque rod
b. Spring assemblies
c. Shock absorber
d. Air springs
e. Leveling valve

Objective 4

a. 6
b. 3
c. 7
d. 2
e. 1
f. 5
g. 4

Objective 5

a. Rolling lobe (or sleeve)
b. Single convolution
c. Triple convolution
d. Double convolution

Objective 6

a. 4
b. 6
c. 5
d. 9
e. 1
f. 3
g. 8
h. 7
i. 2

Objective 7

Descriptions should include the following in student's own words:

a. Visually identify the type of air spring.
b. Check the number molded on the rubber flexible member.
c. Measure the dimensions of the retainer plates.
   - Outside diameter
   - Location and dimensions of studs/blind holes and air fillings
d. Measure the collapsed height of the air spring.

Answers to Written Test

Objective 8

a. I
b. L
c. I
d. P
e. L
f. L
g. P

Objective 9

a. Air exhaust
b. Air outlet
c. Air inlet

Objective 10

a. Million, flexing, leak
b. Large
c. Over-extension
d. No

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 5 through 10.

☐ 4. **Do** Job Sheet 1, "Inspect, Test, and Replace an Air Spring."

☐ 5. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 6. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Steps 3 and 4.

☐ 6. **Study** Information Sheet, Objectives 1 through 4.

☐ 7. **Do** Job Sheet 2, "Inspect and Test an Air Suspension System, Replace the Leveling Valve and Adjust Frame (Ride) Height."

☐ 8. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 9. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Steps 6 and 7.

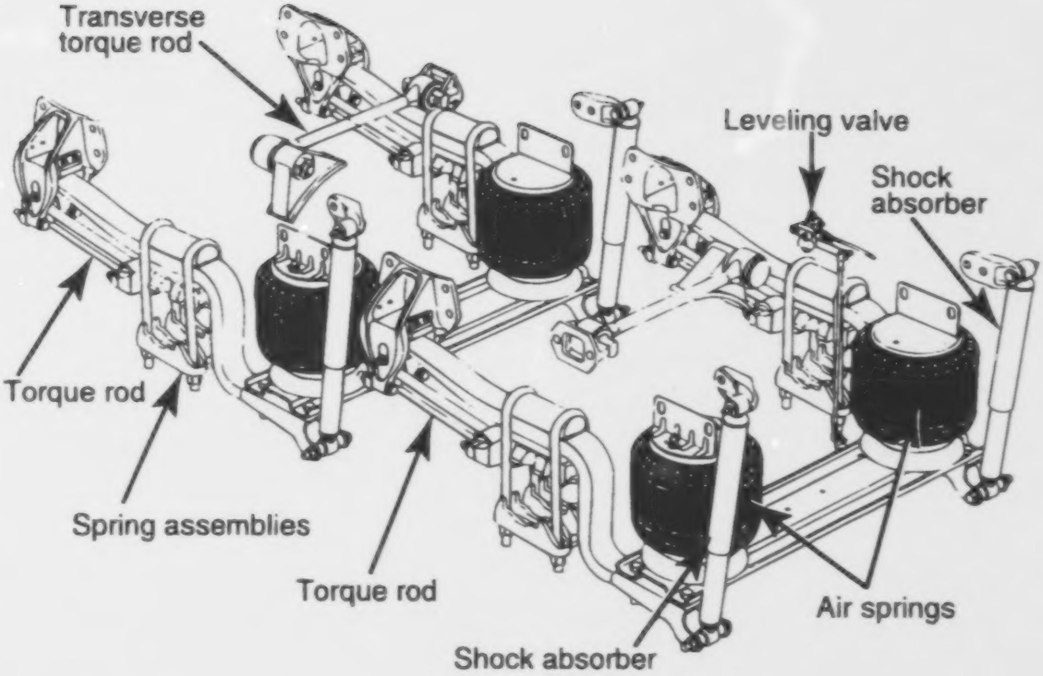
☐ 9. **Check** With instructor for any additional assignments to be completed.

☐ 10. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 11. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

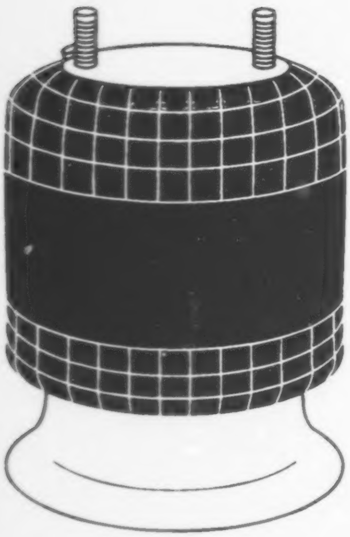
***Permission to duplicate this form is granted.**

Air Suspension Components

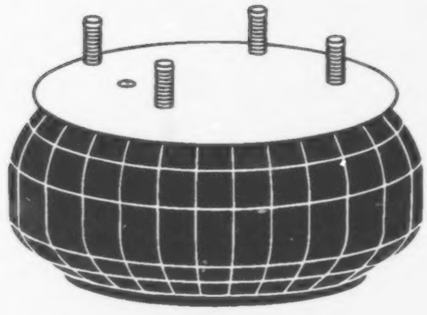

Transverse torque rod
Leveling valve
Shock absorber
Torque rod
Spring assemblies
Torque rod
Air springs
Shock absorber

Courtesy of Hendrickson Truck Suspension Systems

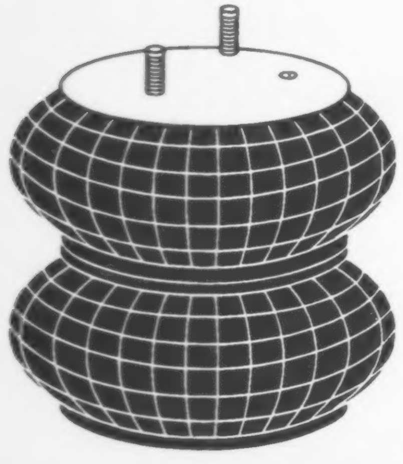
Types of Air Springs



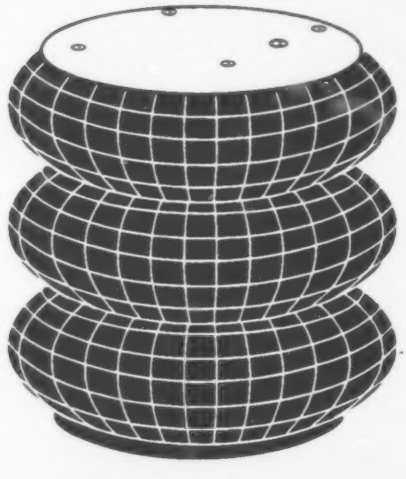
Rolling Lobe (or Sleeve)



Single Convolution

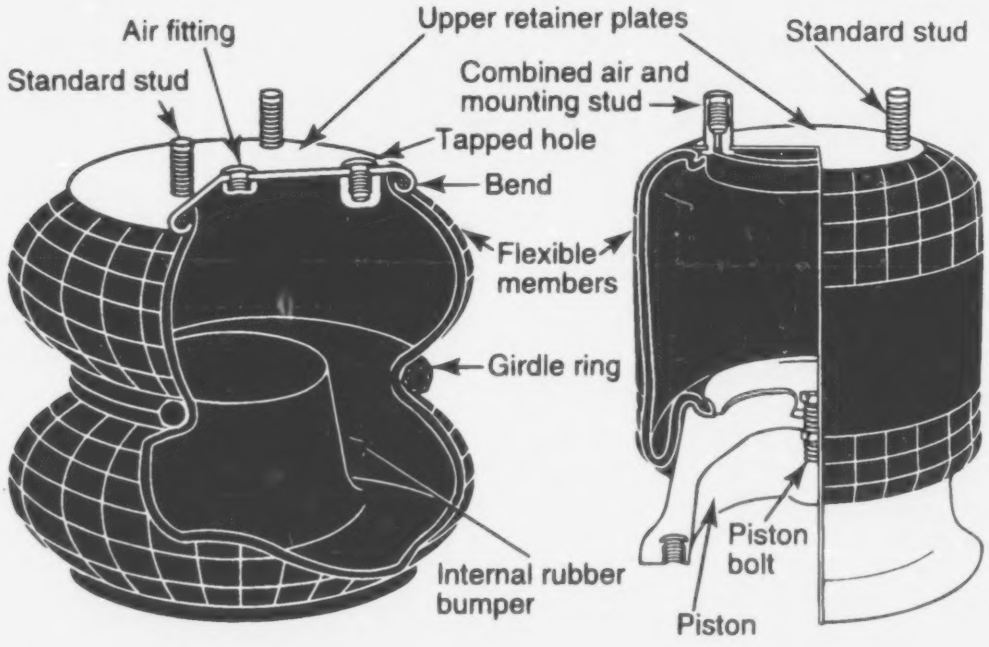


Double Convolution

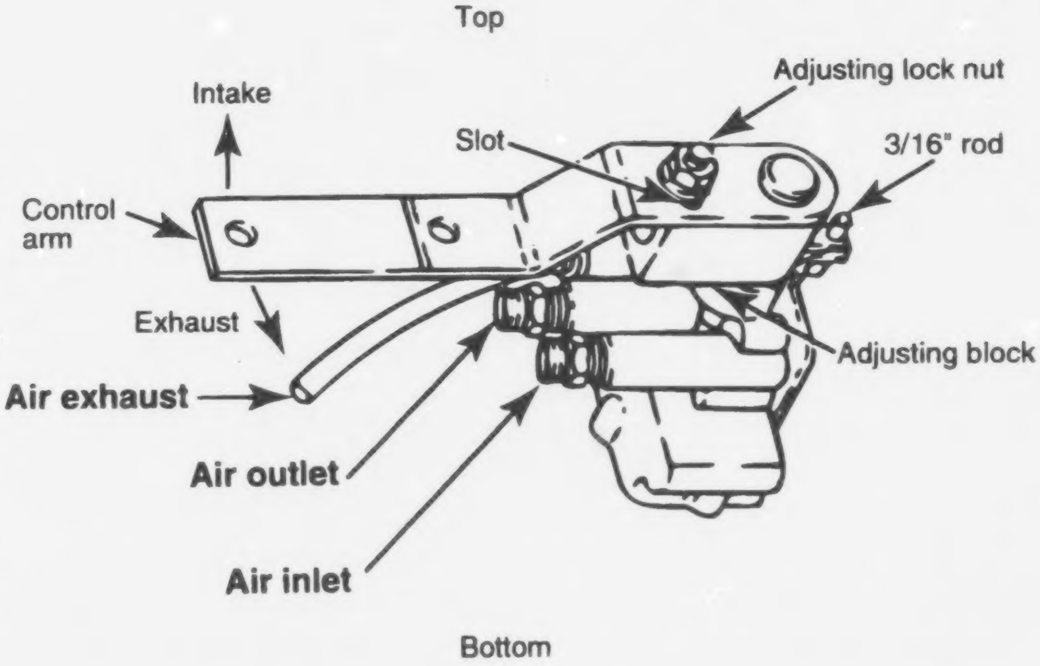


Triple Convolution

Parts of an Air Spring


Air fitting
Standard stud
Upper retainer plates
Standard stud
Combined air and mounting stud
Tapped hole
Bend
Flexible members
Girdle ring
Internal rubber bumper
Piston bolt
Piston

Air Ports of a Leveling Valve


Top
Intake
Adjusting lock nut
Slot
3/16" rod
Control arm
Exhaust
Adjusting block
Air exhaust
Air outlet
Air inlet
Bottom

Courtesy of Peterbilt Motors Company/PACCAR Inc.

TM 4

Unit Contents

Teacher Components

Teacher Page

Suggested Activities . . . 5C–3
Written Test . . . 5C–9
Answers to Written Test . . . 5C–15
Learning Activities Sheet . . . 5C–17

Transparency Masters

1—Toe-In and Toe-Out . . . 5C–19
2—Caster, Camber, and Kingpin Inclination . . . 5C–21
3—Turning Angles . . . 5C–23
4—Rear Axle Alignment . . . 5C–25

Student Components

Student Page

Objective Sheet . . . 5C–3
Information Sheet . . . 5C–5

Job Sheets

1—Perform Pre-alignment Checks . . . 5C–17
2—Check Camber and Kingpin Inclination; Determine Needed Repairs . . . 5C–21
3—Check Caster; Adjust or Repair as Needed . . . 5C–25
4—Check Toe; Adjust as Needed . . . 5C–29
5—Check Rear Axle Alignment; Adjust or Repair as Needed . . . 5C–33
6—Measure and Adjust Pinion Angle . . . 5C–39

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
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- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Visit a vehicle alignment shop so students can see the types of jobs involved in aligning vehicles. Point out the sophisticated equipment and devices used for alignment work. Arrange for a demonstration of the equipment.
- Construct a mock-up of a vehicle front end to demonstrate various alignment terms—toe, caster, camber, and kingpin inclination (KPI). Discuss how toe and caster are adjusted. Also point out that camber and KPI cannot be adjusted. Discuss what repairs would be necessary for camber and KPI.
- Discuss the alignment machine, gauges, tools, and other equipment available in the shop for alignment jobs. Demonstrate how to operate. Discuss any special precautions students should follow to prevent incorrect readings.
- Use an actual vehicle to illustrate turning radius angle and vehicle tracking/axle alignment. Use some marking mechanism (water, colored dust, sand, etc.) so lines are more visible.
- Remind students about the safety rules for working on vehicles and alignment equipment.
- Make sure the appropriate tools, equipment, and service manuals are available for students to use in the job sheets.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *Bee Line Wheel Alignment Service Manual.* Bettendorf, IA: Bee Line Company/Division of McLaughlin Body Co.
- *Hunter Advanced Heavy Truck and Trailer Alignment Course Guide.* St. Paul: Hunter Engineering Company.
- *International Harvester/Navistar Service Manuals, CTS-2680S and 4012A.* Chicago: Navistar International Transportation Corp.
- *Kenworth Maintenance Manual, Form 17057.* Bellevue, WA: PACCAR, Inc., 1987.

- *Mack Front End Alignment (AS029-7M-1277).* Allentown, PA: Mack Trucks, Inc.
- Norman, Ian Andrew, et al. *Heavy-Duty Truck Systems*, 2nd ed. Albany, NY: Delmar Publishers, 1996.
- *Rockwell Maintenance Manual No. 2. "Front Non-Drive Steering Axles."* Troy, MI: Rockwell International Corporation, 1993.
- *Rockwell Parts Failure Analysis, TP-87123.* Troy, MI: Rockwell International Corporation, 1988.
- Schultz, Erich J. *Diesel Equipment I and II.* New York: McGraw-Hill Book Company, 1982.
- *Truck Systems Design Handbook.* Warrendale, PA: Society of Automotive Engineers, Inc., 1992.

Suggested Supplemental Resources

Print Media

- *Truck Wheel Alignment Service Manual*
- *Tandem Alignment Service Manual*

The above are available from:

Bee Line Company
P.O. Box 709
Bettendorf, IA 52722-0709
1-800-553-2010 or 319-332-4066

Electronic Media

- *Alignment Geometry One Training Package (20-783-1)*—Includes a 35-minute videotape, workbook, and test book.

  Note: *Alignment Geometry Two* and *Three* are also available for more in-depth geometry principles.

- *Total Alignment for Trucks, Trailers, and Buses* (1933-T) 11-minute videotape.

The above are available from:

Hunter Engineering Company
Service Center
2531 Metro Boulevard
Maryland Heights, MD 63043-2411
1-800-448-6848 or 314-731-3020

Suggested Activities

- *Vehicle Alignment Factors* (VIDEO-9053). Available from:

  Rockwell International Corporation
  2135 West Maple Road
  Troy, MI 48084
  1-800-535-5560

- *Mack Suspension and Alignment Part 1 Kit* (14-399K)—Includes video and five guidebooks

- *Mack Suspension and Alignment Part 2 Kit* (14-398K)—Includes video and five guidebooks

The above are available from your local Mack Truck service center or contact:

Mack Trucks, Inc.
2100 Mack Blvd.
P.O. Box M
Allentown, PA 18105-5000
610-439-3011

Written Test

Name ____

Date ______________________________ Score__________

Objective 1

Match the terms with their definitions. Definitions continue on the next page.

1. Alignment
2. Camber
3. Caster
4. Kingpin inclination
5. Maximum turning angle
6. Pinion
7. Pinion angle
8. Pythagorean theorem
9. Scrubbing
10. Thrust
11. Thrust angle
12. Thrust lines
13. Toe
14. Turning radius angle

_____ a. Forward or rearward tilt of the kingpin centerline when viewed from the side of the vehicle

_____ b. Condition of tires subjected to extreme friction, especially from misalignment

_____ c. Inward or outward tilt of the top of the tires when viewed from the front of the vehicle

_____ d. Name of a smaller gear and shaft designed to mesh with a larger gear and shaft

_____ e. Marks or tracks that indicate forward movement of the rear wheels; should be parallel to vehicle's centerline

_____ f. Geometry formula that applies only to right (90°) triangles that states: A2 + B2 = C2

_____ g. Degree of movement from a straight-ahead position of the front wheels to either an extreme right or left position; adjusted by stop screws on the steering knuckle

_____ h. Angle between thrust lines and vehicle's centerline

_____ i. Angle measured between the centerline of the kingpin and the vertical position as viewed from the front of the vehicle

_____ j. Characteristic angle built into the steering linkage by the manufacturer to allow for the different radii used by the front wheels during a turn

_____ k. Adjustments made in the relationship between axles, steering and suspension components, and tires to bring them into correct positions

_____ l. Angle of the tires from the true straight-ahead position when viewed from the top of the vehicle

Objective 2

List three purposes of vehicle alignment.

a. ______________________________

b. ______________________________

c. ______________________________

Objective 3

Discuss required times to perform front wheel alignment.

____

____

____

____

____

Objective 4

Complete statements concerning toe-in and toe-out by circling the correct answers.

a. Toe is the angle of the tires from the true straight-ahead position when viewed from the (**side, top**) of the vehicle.

b. When the tire centerline is (**parallel, perpendicular**) with the vehicle centerline, the toe is equal to zero.

c. When the front of the tire points outward from the vehicle, the tire has (**toe-in, toe-out**).

d. Toe-in is designed into the vehicle by the manufacturer to counteract the natural tendency of the tires to (**toe-in, toe-out**) when the vehicle is driven.

e. Too much toe-in wears the (**inner, outer**) edges of tires.

f. Toe is calculated in either degrees, inches, or (**millimeters, feet**).

g. Measuring toe involves marking tires with paint or chalk and measuring the front and back of tires with a (**tape measure, trammel bar**).

Objective 5

Distinguish between true and false statements concerning caster by placing a "T" next to true statements and an "F" next to false statements.

_____ a. Caster is the forward or rearward tilt of the kingpin centerline when viewed from the side of the vehicle.

_____ b. Negative caster indicates the kingpin is tilted rearward.

_____ c. Caster is not a directional stability angle. It only affects tire wear.

_____ d. Caster angle helps the driver return the front wheels to a straight ahead position.

_____ e. When two wheels have different caster angles, the vehicle pulls in the direction of the wheel with more positive caster.

_____ f. Possible causes of incorrect caster are weak (sagging) or broken springs, bent or twisted axle, or unequally tightened spring u-bolts.

_____ g. Caster is adjustable with tapered shims.

Objective 6

Complete statements concerning camber by circling the correct answers.

a. Camber is the inward or outward tilt of the top of the tires when viewed from the (**side, front**) of the vehicle.

b. If the top of the tire tilts outward, it has (**positive, negative**) camber.

c. If the top of the tire tilts inward, it has (**positive, negative**) camber.

d. Incorrect camber angles affect both directional stability and (**kingpin inclination, tire wear**).

e. If there is significant difference in camber from one side of the vehicle to the other, the vehicle will pull to the side with the greater amount of (**positive, negative**) camber.

f. Excessive positive camber causes the tire to wear on its (**inside, outside**) shoulder.

g. Excessive negative camber causes the tire to wear on its (**inside, outside**) shoulder.

h. The camber angle (**is, is not**) adjustable.

Written Test

Objective 7

Distinguish between true and false statements concerning kingpin inclination by placing a "T" next to true statements and an "F" next to false statements.

_____ a. Kingpin inclination is the angle measured between the centerline of the kingpin and the horizontal position (as viewed from the front of the vehicle).

_____ b. Kingpin inclination and camber angle put the approximate center of the tire tread in contact with the road. This reduces steering effort and improves directional stability.

_____ c. Use an alignment machine to check kingpin inclination. Refer to the equipment manufacturer's directions for operating the machine.

_____ d. Kingpin inclination is adjustable.

Objective 8

Complete statements concerning maximum turning angle by filling in the blanks with the correct answers.

a. The maximum turning angle is the degree of movement from a ______________________ position of the front wheels to either an extreme right or left position.

b. This angle can be adjusted ONLY if the manufacturer of the vehicle specifies the adjustment. Never _____________ this angle.

c. Adjustable stop screws located on the ___________ ___________ control this angle. Refer to the service manual for the correct adjustment procedure.

d. Proper turning angle prevents the tires from rubbing against the nearest point on the chassis or the steering gear from _____________ .

Objective 9

Distinguish between true and false statements concerning turning radius angle (Ackermann angle) by placing a "T" next to true statements and an "F" next to false statements.

_____ a. During a turn, the outer wheel of a vehicle must follow a smaller circle than the inner wheel.

_____ b. The turning radius angle is built into the design of the tie rod arms, the tie rod ends, and the cross tube assembly by the manufacturer to give the best possible road contact and to minimize tire wear during turns.

_____ c. The turning radius angle can be checked using an alignment machine with radius plates. Refer to the equipment manufacturer's directions for checking this angle.

_____ d. If the turning radius angle is not within specifications, inspect the wheel bearings for wear and damage. Service as necessary.

Objective 10

Complete statements concerning axle alignment by circling the correct answers.

a. Ideally, the vehicle's axles should be (**parallel, perpendicular**) to the vehicle centerline and the rear wheels should track directly behind the front wheels when the vehicle is moving straight ahead.

b. Any deviation between the centerline and the (**thrust marker, thrust line**) is known as the thrust angle.

c. Positive thrust angle shows tracking to the (**left, right**).

d. Tandem axle vehicles will have a thrust line (**for each rear axle, somewhere between the two rear axles**).

e. Axles out of alignment can cause the steering wheel to rest in an uncentered position, the front tires to scrub and wear quickly, and the vehicle to (**shimmy, oversteer or understeer**) when turning.

Objective 11

Complete statements concerning pinion angle adjustment by circling the correct answers.

a. The pinion is the slope of the centerline of the (**axle pinion shaft, driveshaft**).

b. The working angle of the (**transmission, rear axle**) U-joint is the difference in angles between the engine slope and the driveshaft slope.

c. Working angles must be held within (**one, ten**) degree(s) of each other to prevent driveline vibration problems.

d. Pinion angle may be adjusted by changing the angle of the (**driveshaft, axle seat**).

Written Test

Objective 12

Distinguish between a minor and a major front wheel alignment by checking only those tasks that are performed in a minor alignment.

_____ a. Inspect all systems that affect wheel alignment—tire wear and inflation, wheel bearings, tie rods, steering gear, shock absorbers.

_____ b. Check and adjust wheel bearings.

_____ c. Check and adjust maximum turning angle.

_____ d. If vehicle has power steering, check and adjust pressure relief in power steering system.

_____ e. Check turning radius angle.

_____ f. Check kingpin inclination.

_____ g. Check camber angle.

_____ h. Check and adjust caster angle.

_____ i. Check and adjust toe-in.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 3
b. 9
c. 2
d. 6
e. 12
f. 8
g. 5
h. 11
i. 4
j. 14
k. 1
l. 13

Objective 2

Any three of the following:

a. To correct steering and tire wear conditions
b. To maintain reliable and stable steering
c. To maintain steering handling
d. To maximize life of tires and suspension parts

Objective 3

Answers should include the following in student's own words:

a. Every 200,000 miles (320,000 km) or 24 months (normal maintenance)
b. When the vehicle does not steer correctly
c. When tires are wearing rapidly or unusually
d. After extremely heavy service or severe impact loads

Objective 4

a. Top
b. Parallel
c. Toe-out
d. Toe-out
e. Outer
f. Millimeters
g. Trammel bar

Objective 5

a. T
b. F
c. F
d. T
e. F
f. T
g. T

Objective 6

a. Front
b. Positive
c. Negative
d. Tire wear
e. Positive
f. Outside
g. Inside
h. Is not

Answers to Written Test

Objective 7	a. F b. T c. T d. F
Objective 8	a. Straight-ahead b. Increase c. Steering knuckle d. Bottoming
Objective 9	a. F b. T c. T d. F
Objective 10	a. Perpendicular b. Thrust line c. Right d. For each rear axle e. Oversteer or understeer
Objective 11	a. Axle pinion shaft b. Transmission c. One d. Axle seat
Objective 12	a, b, i

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 3.

☐ 4. **Do** Job Sheet 1, "Perform Pre-Alignment Checks."

☐ 5. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 6. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Steps 3 and 4.

☐ 6. **Study** Information Sheet, Objectives 6 and 7.

☐ 7. **Do** Job Sheet 2, "Check Camber and Kingpin Inclination; Determine Needed Repairs."

☐ 8. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 9. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Steps 6 and 7.

☐ 9. **Study** Information Sheet, Objective 5.

☐ 10. **Do** Job Sheet 3, "Check Caster; Adjust or Repair as Needed."

☐ 11. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 12. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Steps 9 and 10.

☐ 12. **Study** Information Sheet, Objective 4.

Learning Activities Sheet

☐ 13. **Do** Job Sheet 4, "Check Toe; Adjust as Needed."

☐ 14. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 15. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 4 and repeat Steps 12 and 13.

☐ 15. **Study** Information Sheet, Objectives 8 through 10.

Optional

☐ 16. **View** Videotapes entitled "Total Alignment for Trucks, Trailers, and Buses," and "Vehicle Alignment Factors."

☐ 17. **Do** Job Sheet 5, "Check Rear Axle Alignment; Adjust or Repair as Needed."

☐ 18. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 19. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 5 and repeat Steps 15 and 16.

☐ 19. **Study** Information Sheet, Objectives 11 and 12.

☐ 20. **Do** Job Sheet 6, "Measure and Adjust Pinion Angle."

☐ 21. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 22. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 6 and repeat Steps 19 and 20.

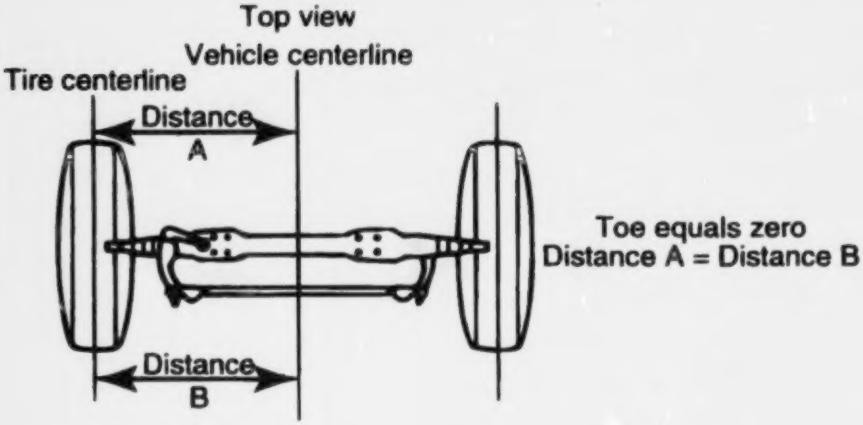
☐ 22. **Check** With instructor for any additional assignments to be completed.

☐ 23. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

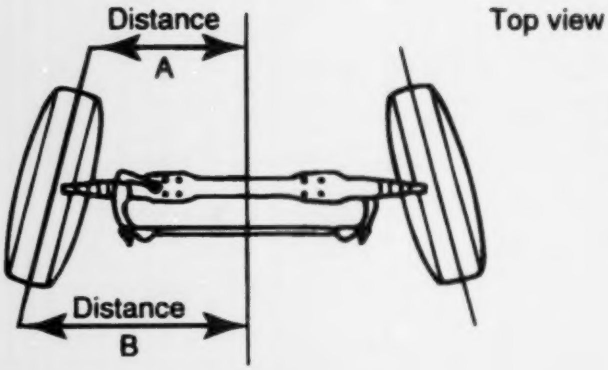
☐ 24. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

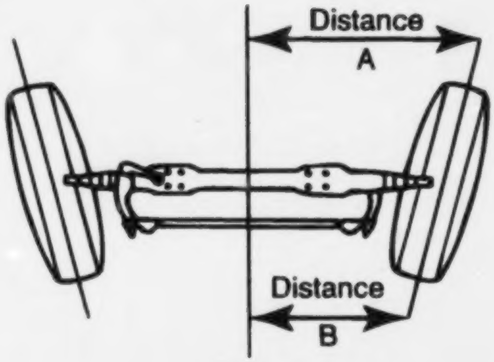
Toe-In and Toe-Out


Top view
Vehicle centerline
Tire centerline
Distance A
Distance B
Toe equals zero
Distance A = Distance B

Toe Equals Zero


Distance A
Top view
Distance B

Toe-in
Distance A < Distance B

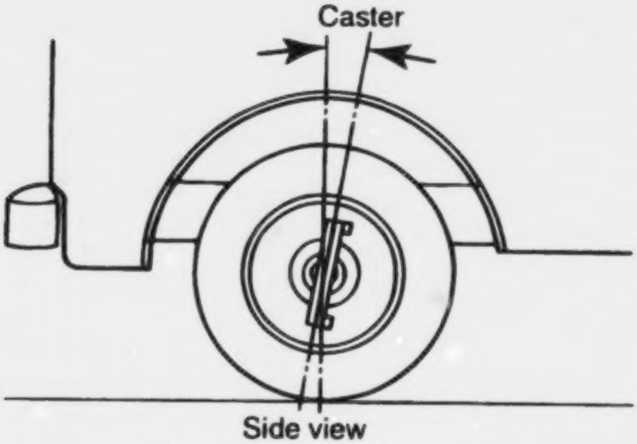

Distance A
Distance B

Toe-out
Distance A > Distance B

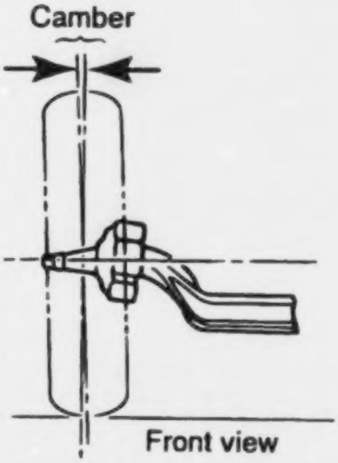
Toe-In **Toe-Out**

Courtesy of Rockwell Heavy Vehicle System, Inc.

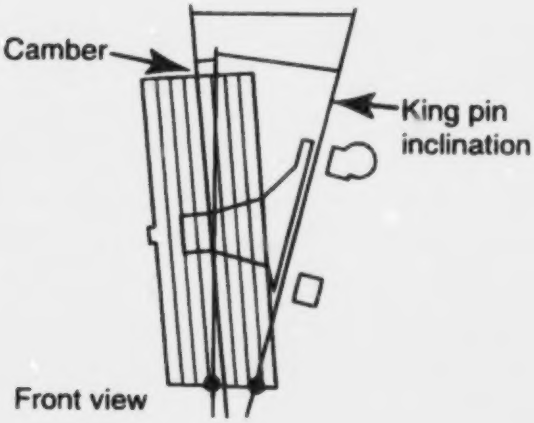
Caster, Camber, and Kingpin Inclination


Caster
Side view

Caster


Camber
Front view

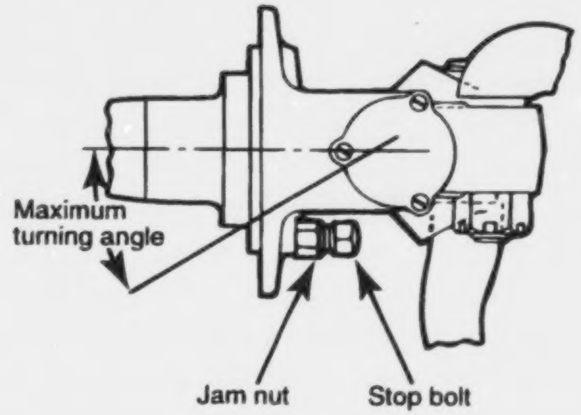
Camber


Camber
King pin inclination
Front view

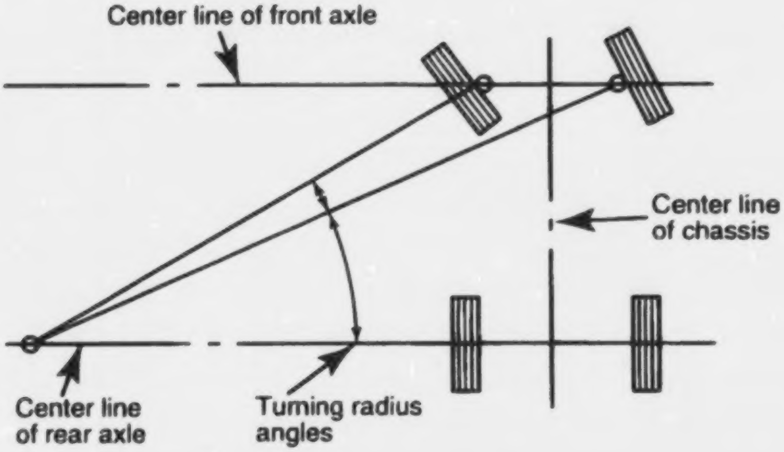
Kingpin Inclination

Courtesy of Rockwell Heavy Vehicle System, Inc.

Turning Angles


Maximum
turning angle
Jam nut
Stop bolt

Maximum Turning Angle

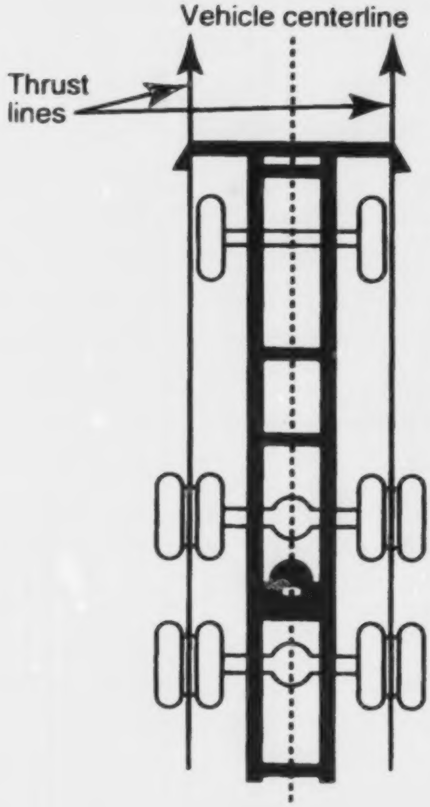

Center line of front axle
Center line
of chassis
Center line
of rear axle
Turning radius
angles

Turning Radius Angle

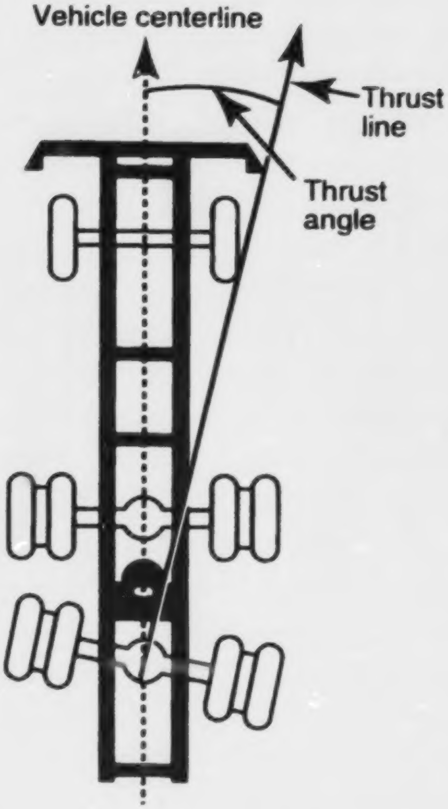
Courtesy of Rockwell Heavy Vehicle System, Inc.

TM 3

Rear Axle Alignment


Vehicle centerline
Thrust lines

Correct Thrust Lines


Vehicle centerline
Thrust line
Thrust angle

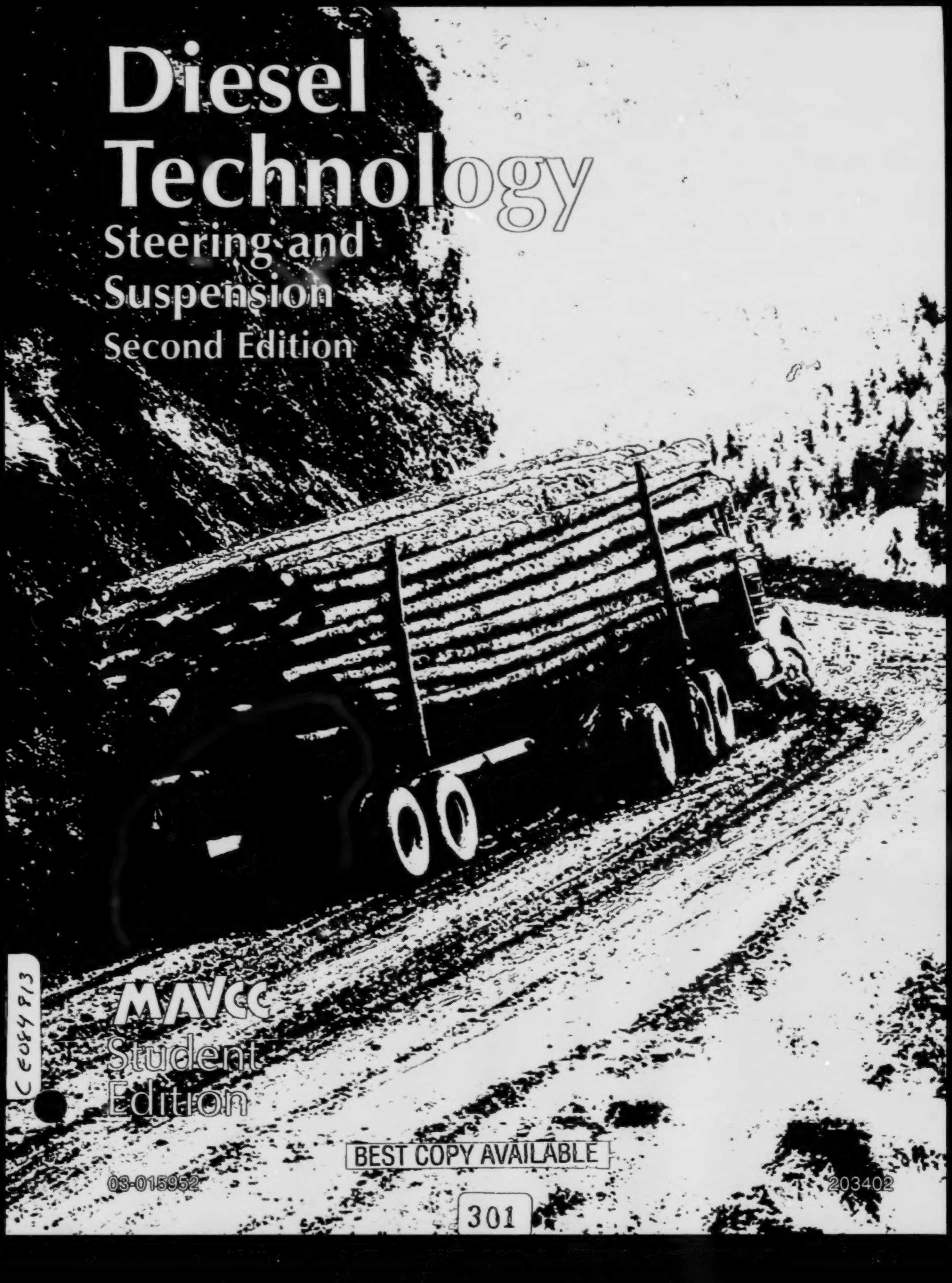
Incorrect Thrust Lines

Courtesy of Rockwell Heavy Vehicle System, Inc.

Diesel Technology

Steering and Suspension

Second Edition



MAVCC

Student Edition

CE054 913

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Diesel Technology: Steering and Suspension

Student Edition

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Objective Sheet

Unit Objective

After completing this unit, the student should be able to inspect and adjust cab components and determine needed repairs. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to cab components with their definitions.
2. Distinguish between the two basic cab designs.
3. Describe optional features on cabs.
4. Complete statements concerning vehicle identification numbers.
5. Identify parts of a cab exterior.
6. Identify parts of a cab interior.
7. Match cab instruments and controls with their correct descriptions.
8. List emergency safety equipment located in the cab.
9. List types of driver seats.
10. Identify main components of an air-suspended seat.
11. Match components of seat belts with their correct descriptions.
12. Distinguish between types of cab mounts.
13. List the types of cab lifting/tilting mechanisms.
14. Complete statements concerning safety rules to follow when working on cabs.
15. Inspect, test, and adjust cab air suspension components and determine needed repairs. (Job Sheet 1)
16. Inspect, test, and adjust driver's air seat components and determine needed repairs. (Job Sheet 2)

Information Sheet

Objective 1

Terms and definitions

a. **Cab**—The driver-/passenger-carrying compartment

b. **Cab-over-engine (COE)**—Type of cab design in which engine is directly under cab

c. **Clearance (marker) lights**—Small amber and red lights attached to the cab and trailer to indicate overall clearance at night

d. **Fairing**—Member or structure whose primary function is to produce a smooth outline and to reduce drag

e. **Fascia**—Flexible material commonly used as a bumper cover

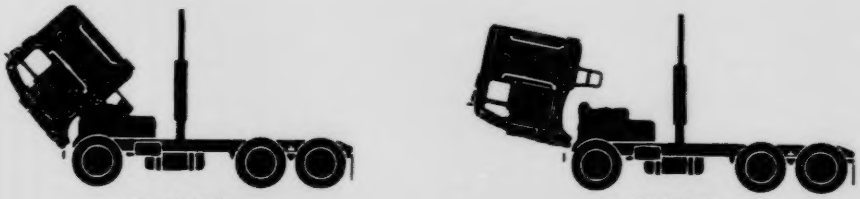
f. **Glider kit**—New cab and chassis components that are used to replace damaged components

g. **Reflectors**—Glass or plastic prism lenses that reflect light

h. **Sleeper cab**—Type of cab that contains an optional bed unit for sleeping

i. **Tilting**—Process of raising the cab on a cabover design to a partial or full open position

Figure 1



Partial Tilt (35°-45°)

Full Tilt (70°-80°)

Courtesy of Freightliner Corporation

Objective 2

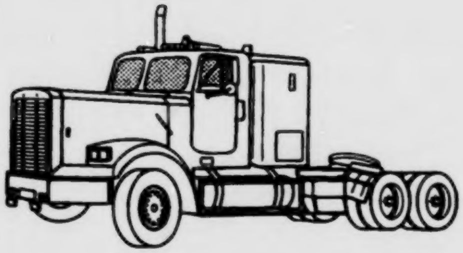
Basic cab designs

a. Conventional

- Cab sits behind the engine.
- Offers driver a smoother ride and more protection because frame and engine are out front

- Provides driver better access to and more room for sleeper
- Hood is tilted forward (or can be removed) for easy access to engine. Latching mechanism is located at rear of hood, next to cab.

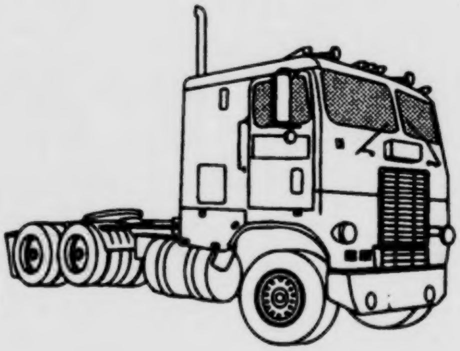
Figure 2



b. Cab-over-engine (COE) or cabover

- Cab is located directly over the engine.
- Driver is seated as far forward as possible which provides greater visibility.
- Shorter wheelbase allows for easier handling in traffic.
- Allows easier access to transmission
- Entire cab must be tilted up and forward before technician can work on engine.

Figure 3



Objective 3

Optional features on cabs

a. Sleepers

- Consist of bed or bunk beds for drivers' and/or passengers' convenience and comfort when sleeping
- Available on either cab design

b. Appliances

- May include refrigerators, microwaves, and radios for the driver's convenience and comfort when traveling
- Must be secured so they won't move during a sudden stop

c. Special aerodynamic design features

- Used to improve fuel efficiency by reducing wind resistance
- Includes wind deflectors, roof shields, and special side fairing around fuel tanks

d. Heated mirrors—Used to prevent fogging and icing on outside mirrors

e. Cruise control—Used to regulate "cruising" speed

Objective 4

Vehicle identification numbers (VIN)

a. Are numbers required by law which are assigned to vehicles by manufacturers primarily for registration and identification purposes

b. Consist of 17 digits made up of a combination of numbers and letters

Example: 1XK 9D2X96 L S345678

Model Year

L = 1990
M = 1991
N = 1992
P = 1993
R = 1994
S = 1995
T = 1996
V = 1997
W = 1998
X = 1999

c. Identify the model year, manufacturing plant, and vehicle serial number

d. Located in various places near the driver's door, usually on the latching edge of the cab door or on the cab door frame above the hinge on conventional cabs or on the bulkhead panel to the left of the driver on COE vehicles

Objective 5

Parts of a cab exterior

a. Windshield and weather strip seal

b. Windshield wipers

c. Driver and passenger door assemblies (panels, handles, latches, hinges, and seals)

d. Door window and rear window glass and seals

e. Baggage/luggage door

f. Sleeper and sleeper door (optional)

g. Cab entry steps and hand holds

h. Mirrors

i. Cab rear suspension

j. Cab front mounts

k. Cab tilt pump

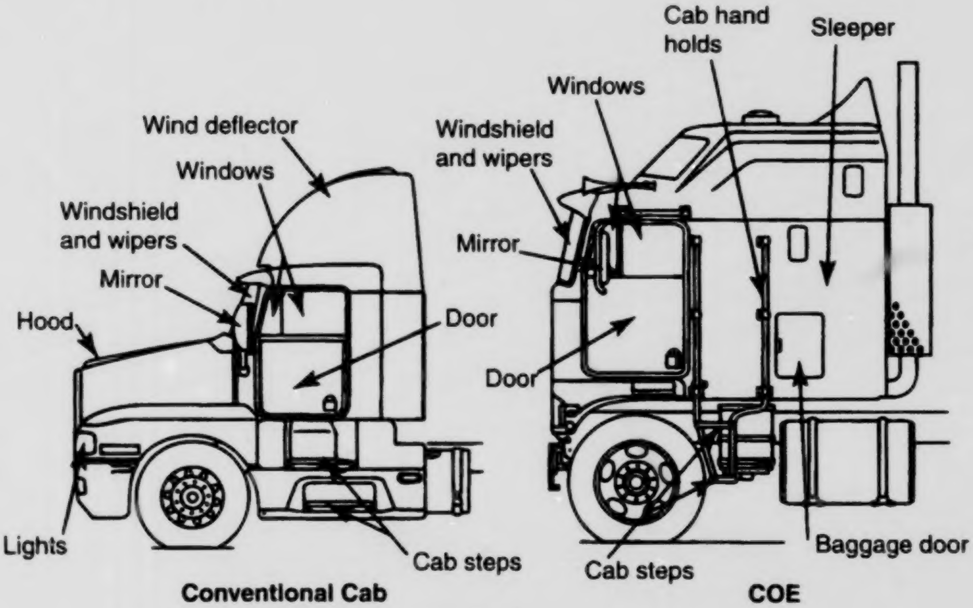
l. Hood

m. Wind deflectors

n. Tunnel liner

o. Lights and reflectors

Figure 4


Wind deflector
Windows
Windshield and wipers
Mirror
Hood
Door
Lights
Cab steps
Conventional Cab
Cab hand holds
Sleeper
Windows
Windshield and wipers
Mirror
Door
Cab steps
Baggage door
COE

Courtesy of Kenworth Truck Company/PACCAR Inc.

310

Objective 6

Parts of a cab interior

a. Driver and passenger seat(s)

b. Seat belts

c. Instrument gauges and control console mounted on dashboard

d. Steering column, steering wheel, and controls mounted on steering column

e. Window locks and opening/closing controls or regulators (manual or electric)

f. Ash tray and cigarette lighter

g. Transmission shift control lever

h. Pedals—Accelerator, brake, and clutch

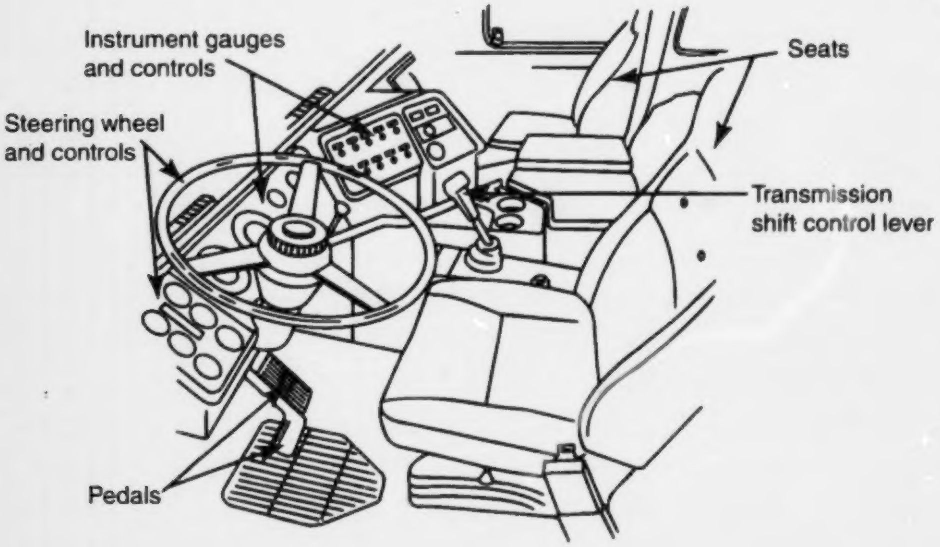
i. Climate controls and vents

j. Required and optional safety equipment

k. Overhead panel with radio, air, horn and other controls

l. Optional features—Computer (trip monitoring), air bags, sleeper, etc.

Figure 5


Instrument gauges and controls
Seats
Steering wheel and controls
Transmission shift control lever
Pedals

311

Information Sheet

Objective 7

Cab instruments and controls

a. **Engine gauges**

- **Tachometer**—Measures the engine speed in revolutions per minute (RPM); used for matching driving speed and gear selection
- **Oil pressure gauge**—Indicates operating pressure of engine oil
- **Oil temperature gauge**—Indicates temperature of engine oil
- **Water temperature gauge**—Indicates temperature of engine coolant
- **Voltmeter**—Shows the voltage output of the vehicle's electrical system (normally 12-14 volts)
- **Ammeter**—Indicates balance of vehicle's electrical system (normally 0)

b. **Operational gauges**

- **Speedometer**—Indicates vehicle's speed in miles per hour and kilometers per hour
- **Odometer**—Records the miles traveled

  Note: Some vehicles also have a trip odometer that can be reset to record separate mileages.

- **Air reservoir pressure gauge**—Indicates the amount of air pressure in the brake system in pounds per square inch (psi); usually has a green pointer to show the front reservoir air pressure and a red pointer to indicate pressure in the rear reservoir
- **Air application pressure gauge**—Shows how much air pressure is being applied from the foot brake valve or trailer brake hand valve
- **Fuel tank level gauge**—Shows the approximate amount of fuel in the fuel tanks

c. **Secondary instrument gauges**—Vary according to vehicle manufacturer; may include:

- **Pyrometer**—Indicates engine exhaust gas temperature; used to determine engine output
- **Manifold pressure gauge**—Indicates engine output by showing the amount of turbo boost
- **Axle temperature gauge**—Indicates the temperature of the lubricant in the vehicle's axle(s)
- **Transmission temperature gauge**—Shows the temperature of the oil in the transmission

d. **Operational switches**

- **Ignition switch**—Used primarily to turn on the engine; also has an accessory position to turn on accessory power without turning on the engine
- **Air tank heat switch**—Used to help remove moisture and to prevent freezing in the air system
- **Engine fan switch**—May be switched from manual to automatic

> Caution: When the fan switch is on manual, the fan will turn on immediately when the engine is started. When the fan switch is on automatic, the fan will turn on when the engine coolant reaches a set temperature of about 200° F. This can happen suddenly. Watch out!

- **Air suspension deflate switch (dump valve)**—For exhausting the air in the suspension if the truck must be lowered to get under a trailer
- **Interaxle differential lock switch**—Allows differential action between the forward rear and the rear rear driving axles; may be locked when operating on surfaces with poor traction; is unlocked for normal conditions
- **Fifth wheel lock switch**—Used to adjust a sliding fifth wheel for better weight distribution
- **Accessory controls**—For accessory items not used when the vehicle is operating on the highway, such as deep reduction and trailer dump

e. **Lighting switches**—Include switches for headlights, panel lights, clearance lights, side and tail lights, dome light, trailer clearance lights, and fog lights

f. **Brake controls**

- **Parking brake control valve (Yellow)**—Pulled out to set the parking brake on the tractor
- **Trailer air supply valve (Red)**—Will automatically pop out to set the trailer parking brakes when the tractor parking brakes are set
- **Tractor park only valve (Blue)**—Used to set the parking brake for the tractor when it is disconnected from the trailer
- **Trailer brake hand control**—Provides air pressure to apply the trailer brakes only; operates independently of the foot brake valve
- **BrakeSaver® switch**—Provides auxiliary braking to slow the vehicle and to control speed on long grades; only used on vehicles with Caterpillar engines

    - **Engine (Jake® brake) switch**—Provides progressive brake retarding; only used on some vehicles

g. **Visible warning indicator lights**—Include lights for low oil pressure, high water temperature, low air pressure, low coolant, anti-lock problems, and several others

h. **Heater/Air conditioning controls**—Consist of levers and switches to control air direction (floor, vent, bi-level, windshield), fan blower speed, temperature level, and air selection (fresh or recirculating)

Note: The sleeper unit will have separate controls.

i. **Steering column-mounted controls**

    - **Turn signals**—Used to turn on blinking indicator lights to let others know the driver is planning to turn the vehicle
    - **Hazard flasher**—Activates all turn signals to flash at once
    - **Windshield wiper/washer controls**—May be located on the dash or the steering column
    - **Electric horn button**—Used to sound the horn
    - **Tilting lever/telescoping ring**—Allows the steering wheel to be adjusted to improve driver comfort
    - **Headlight dimmer switch**—May be located on the steering column or on the floor; used to select high beam or low beam headlights

Objective 8

Types of emergency safety equipment located in the cab

a. Required by Department of Transportation (DOT)

    - Fire extinguisher (multipurpose type)
    - Warning devices (at least 3); several types may be used such as red reflectors, emergency flares, red flags, red reflective triangles, or electric lanterns.

b. Optional

    - Spare fuses
    - Jumper cables
    - First aid kit
    - Telephone

Objective 9

Types of driver seats

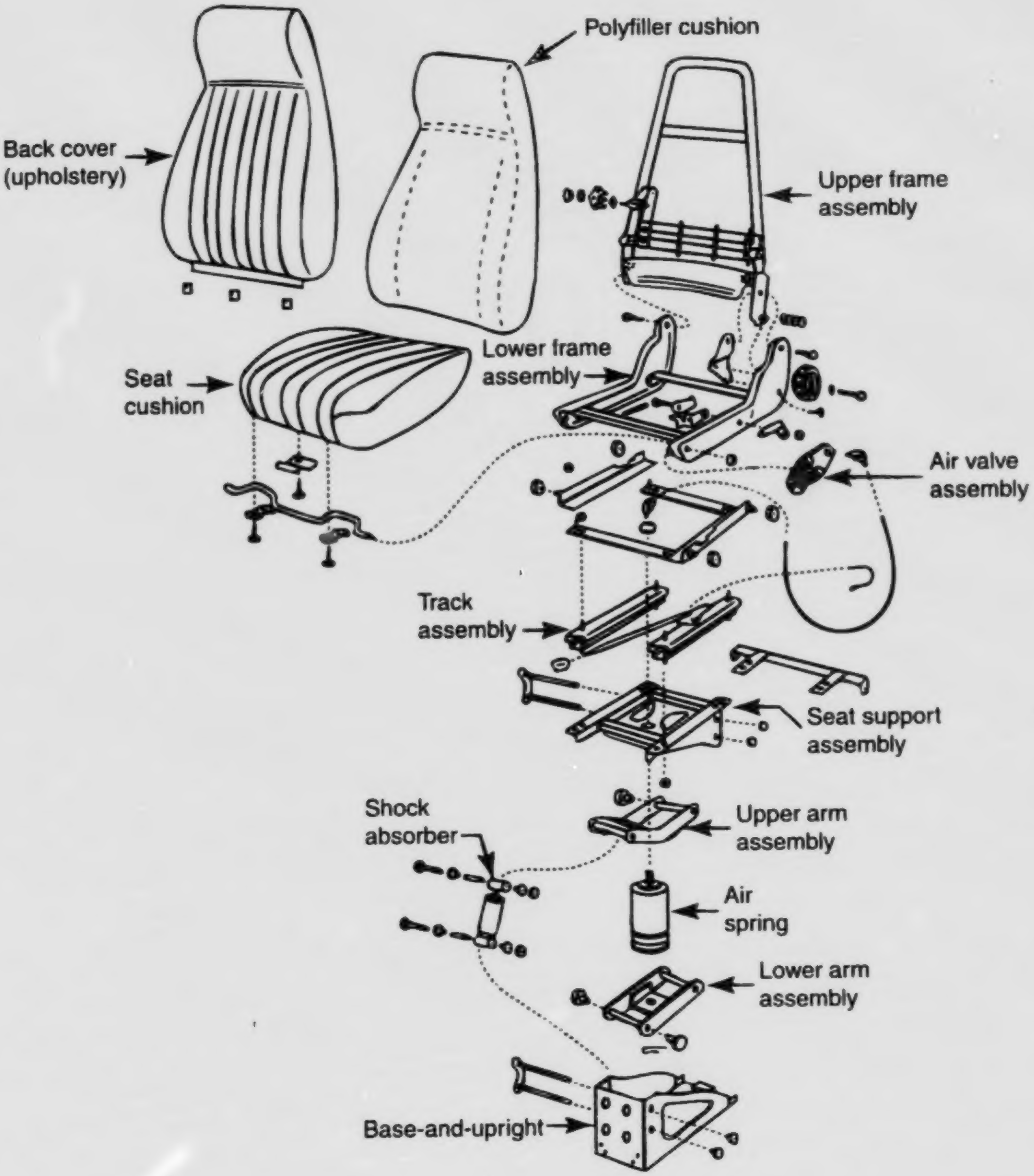
a. Air-suspended seat

b. Spring-suspended seat

Objective 10

Main components of an air-suspended seat

Figure 6


Polyfiller cushion
Back cover (upholstery)
Upper frame assembly
Seat cushion
Lower frame assembly
Air valve assembly
Track assembly
Seat support assembly
Shock absorber
Upper arm assembly
Air spring
Lower arm assembly
Base-and-upright

Courtesy of Freightliner Corporation

Information Sheet

Objective 11

Components of seat belts and their descriptions

a. **Webbing**—Narrow fabric woven with continuous yarns; very strong but can be damaged when caught in the door and will need replacement

b. **Buckle**—Quick-release mechanism which receives the latch plate for fastening

c. **Latch plate (tongue)**—Flat, metal piece that inserts into the buckle for fastening

d. **Adjustment hardware**—Metal or rigid plastic parts that allow for adjusting the size of a seat belt to fit the user

e. **Attachment hardware**—Metal parts designed for securing the webbing to the vehicle; is attached in two or three points depending on the type of seat belt

- **Two-point seat belt**—Is a lap belt designed for pelvic restraint
- **Three-point seat belt**—Is a lap and shoulder belt for pelvic and upper torso restraint

Figure 7

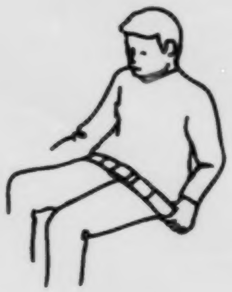
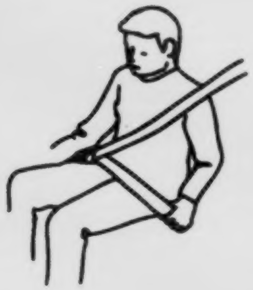


Figure 8



f. **Emergency locking retractor**—Device that stores unused webbing and through which webbing rolls in and out during the fastening process; also contains a locking mechanism so webbing will not continue to roll out during an emergency

g. **Tether belt and anchor bracket**—Attach buckle end of the seat belt to the cab floor and seat frame; used on suspension seats to prevent excessive movement of the seat

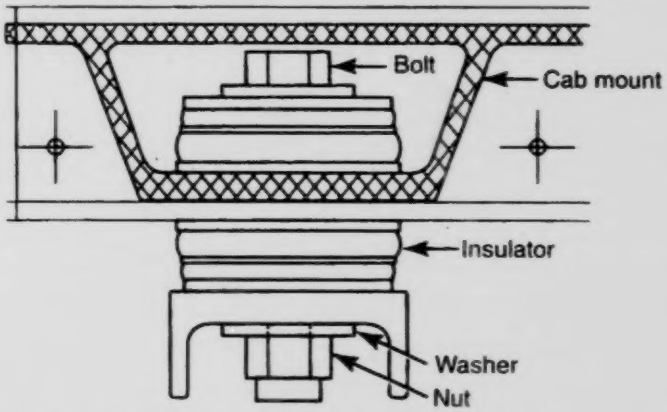
Note: Some seat belts also contain a locking device that will relieve shoulder restraint tension for extra comfort.

Objective 12

Types of cab mounts

a. Stationary (solid) cab mount

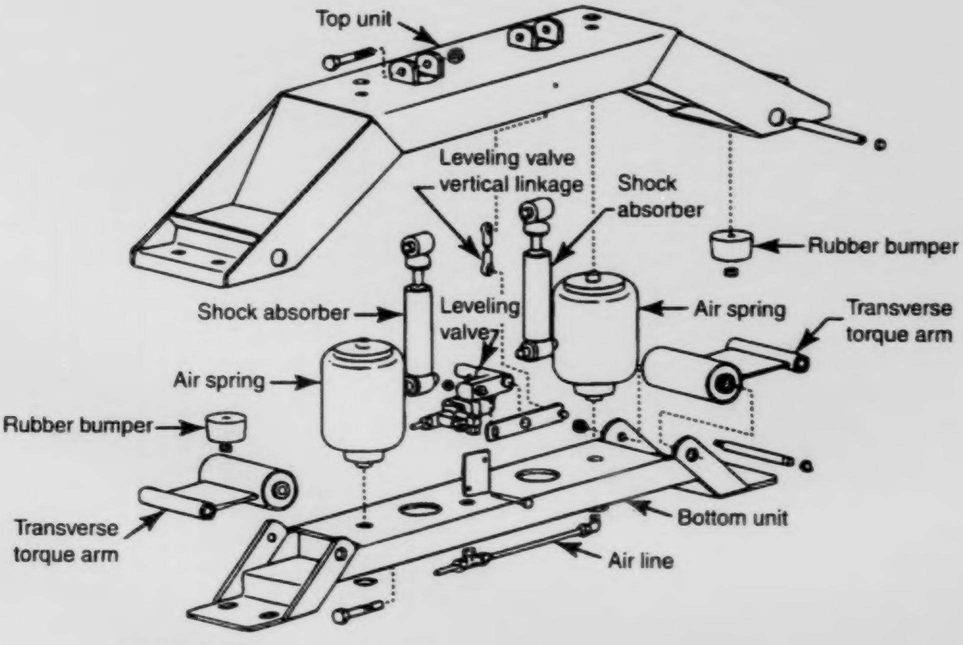
Figure 9


Bolt
Cab mount
Insulator
Washer
Nut

Courtesy of Peterbilt Motors Company/PACCAR Inc.

b. Air suspension cab mount

Figure 10


Top unit
Leveling valve vertical linkage
Shock absorber
Rubber bumper
Shock absorber
Leveling valve
Air spring
Transverse torque arm
Air spring
Rubber bumper
Transverse torque arm
Bottom unit
Air line

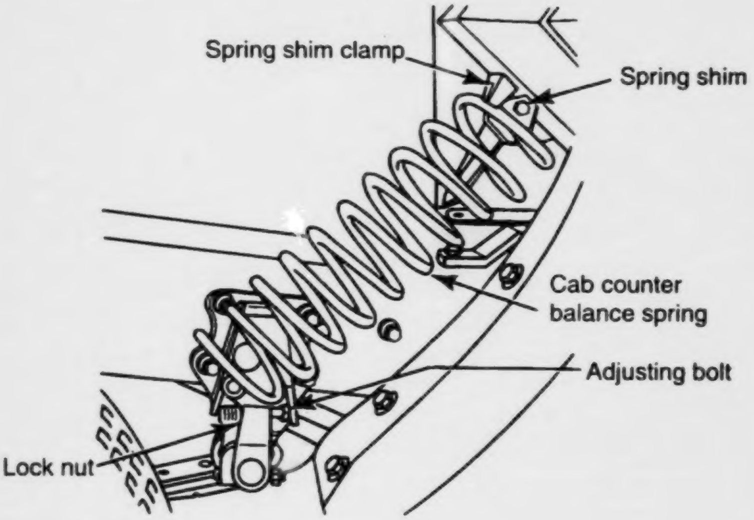
Courtesy of Freightliner Corporation

Objective 13

Types of cab lifting/tilting mechanisms

a. Manual lift

Figure 11

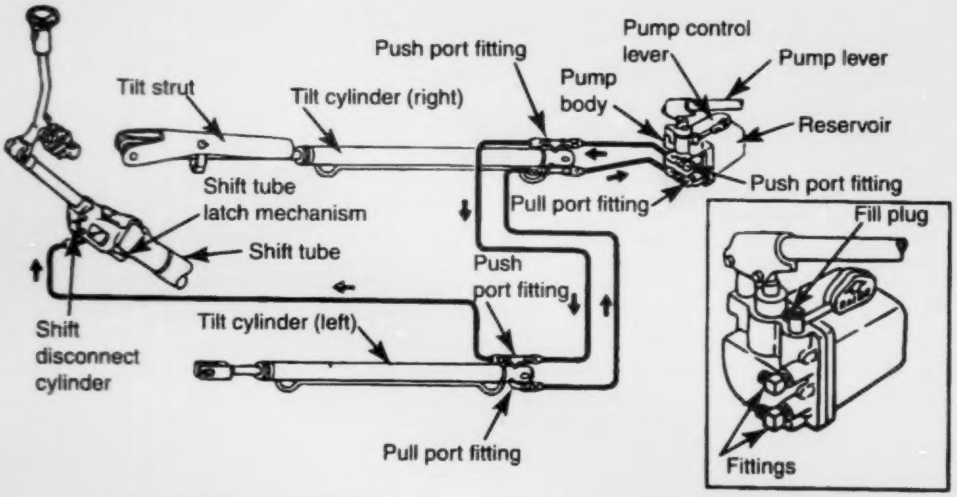

Spring shim clamp
Spring shim
Cab counter balance spring
Adjusting bolt
Lock nut

Courtesy of Mack

b. Hydraulic lift

Note: Hydraulic lifts may be also assisted by air.

Figure 12


Push port fitting
Pump control lever
Pump lever
Tilt strut
Tilt cylinder (right)
Pump body
Reservoir
Push port fitting
Pull port fitting
Shift tube latch mechanism
Shift tube
Fill plug
Push port fitting
Shift disconnect cylinder
Tilt cylinder (left)
Pull port fitting
Fittings

Courtesy of Freightliner Corporation

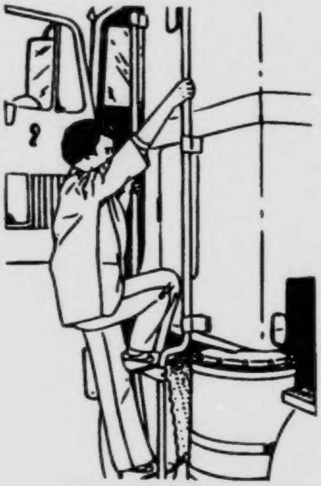
Objective 14

Safety rules to follow when working on cabs

a. Never jump out of a cab! Use the hand holds.

b. When getting into and out of the cab, always maintain at least three points of contact with your hands on the hand holds (or grab handles) and your feet on the steps or ground.

Figure 13



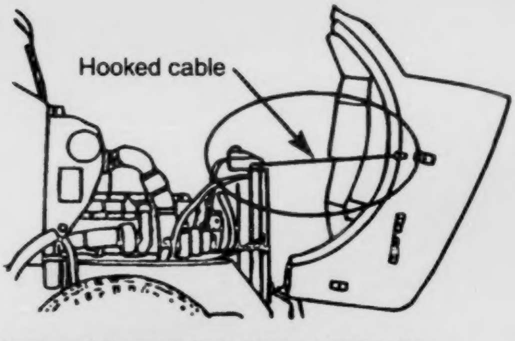
Courtesy of Kenworth Truck Company/PACCAR Inc.

c. Also maintain at least three points of contact when climbing onto and off the deck plate behind the cab. Watch for slippery surfaces. Be careful not to slip and fall.

d. Before tilting or lifting any hood, make sure the engine is not running and the parking brake has been set.

e. Always attach the safety cable on a conventional hood to keep the hood open and to keep it from falling.

Figure 14



Courtesy of Kenworth Truck Company/PACCAR Inc.

f. For COE cab

- Before tilting, make sure there are no people or objects in the way. Check the clearance above and ahead of the cab leaving enough room for roof antenna, roof fairing, and side fairing. Watch out for branches, power lines, electrical wires, lights, and other vehicles.
- Before tilting, make sure shift lever is in neutral, all loose items in the cab and luggage compartments are secured or removed, and the doors are closed.
- Before getting under the cab, always make sure the safety lock bar is fully engaged. An unsecured cab could cause a serious or fatal accident.
- Before performing any work on the cab, make sure it is in the mechanically locked position or in the full tilt position.
- Be sure no one tries to bleed the hydraulic system with the cab tilted. This will defeat all safety features, and the cab can fall and crush anyone under it.

g. Always make sure hood is latched securely when you finish working on any cab.

Objective 15

Job Sheet 1—Inspect, Test, and Adjust Cab Air Suspension Components and Determine Needed Repairs

Name ______________________ Attempt Number ______

Date ______________________ Overall Rating ______

Evaluation Criteria	Rating
• Correct procedures identified for assignment vehicle	______
• Procedures completed correctly	______
• Proper tools used correctly	______
• Safety precautions observed	______
• Installed equipment functions correctly	______
• Serviced equipment meets specifications	______
• Clean-up and follow-up actions adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Truck-tractor with cab air suspension
- Steel ruler
- Soapy water in spray bottle
- Hand tools
- Others as specified in service manual

Guidelines

- The cab air-suspension system absorbs road shocks and compensates for changing cab loads.

- The major parts of the air-suspension system are two air springs, a leveling valve, a top unit mounted to the cab, a lower unit mounted to the frame rails, and two shock absorbers.

- Together with the leveling valve, the springs compensate for changes in cab load by maintaining the correct distance between the rear of the cab and the frame rails.

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Set parking brake, remove ignition key, and chock wheels. Make sure air pressure is over 100 psi.

☐ 4. Locate the main components of the cab air-suspension system including the shock absorber, leveling valve, leveling valve linkage, and air bags.

☐ 5. Check for air leakage by applying soapy water to fittings, air lines, air bags, and the leveling valve.

☐ 6. Tighten loose fittings to stop leakage; replace worn or damaged parts.

☐ 7. With vehicle air pressure at 100 psi, measure the vertical distance from the top of the frame rail upper flange to the bottom of the rear cab-mount angle. Check service manual for correct distance.

  ☐ a. If the distance is correct, the leveling valve does not need any adjustment.

  ☐ b. If the distance is not correct, the leveling valve linkage will need to be adjusted to the correct distance. Follow the procedure in the service manual to make the leveling valve adjustment.

☐ 8. After leveling valve adjustment, recheck the vertical distance making sure the distance is correct. Tighten all fasteners to correct torque.

☐ 9. Record any additional repair on the shop ticket.

☐ 10. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

322

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________

Address ____________

Phone # ____________

Date In ____________

Date Out ____________

JOB TICKET

Customer Name ____________

Customer Address ____________

Customer Phone # ____________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________

Services/repairs made: ____________

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________ Date ____________

Technician ____________

Supervisor ____________

Objective 16

Job Sheet 2—Inspect, Test, and Adjust Driver's Air Seat Components and Determine Needed Repairs

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Correct procedures identified for assignment vehicle	______
• Procedures completed correctly	______
• Proper tools used correctly	______
• Safety precautions observed	______
• Installed equipment functions correctly	______
• Serviced equipment meets specifications	______
• Clean-up and follow-up actions adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Vehicle equipped with air seat
- Wood block
- Soapy water in spray bottle
- Hand tools
- Others as specified in sevice manual

Guidelines

- The air suspension seats use a free-moving support system to keep the driver from taking the full brunt of the jolts coming through the chassis to the cab. Air suspension seats do this very effectively with an air bag/cushion and shock absorber assembly, using compressed air from the vehicle's air system.

- The seat belt assembly is an important part of a vehicle's occupant protection system and must be properly installed and maintained to assure its usability and satisfactory performance in the event of a collision.

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Set parking brake, remove ignition key, and chock wheels. Make sure air pressure is over 100 psi.

☐ 4. Identify the main components of the air seat including the air bag, shock, air valve, and frame assembly.

☐ 5. Check fittings, air lines, air spring, and air valve with soapy water for air leaks.

☐ 6. Tighten loose fittings to stop leakage. If air valve or air spring is leaking, follow procedure in service manual to remove and install.

☐ 7. Check frame assembly for worn and damaged parts and record needed repair on shop ticket.

☐ 8. Follow the SEAT BELT ASSEMBLY CHECKLIST that follows to inspect seat belts.

☐ 9. Replace seat belt components as needed.

Note: Seat belt replacements should be made with units that are authorized by the vehicle manufacturer.

☐ 10. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

SEAT BELT ASSEMBLY CHECKLIST

Vehicle Type ____________________
Manufacturer's S/N ____________________
Date of Manufacture ____________________
Fleet Name ____________________
Manufacturer ____________________
Fleet I.D. No. ____________________
Inspection Date ____________________
Mileage ____________________

1. Accessibility

   a. Are belts accessible to and not caught under or behind the seat? ☐ Yes ☐ No

   Comments: ____________________

2. Hardware

   a. Are all fasteners and hardware in good condition and tightened properly? ☐ Yes ☐ No

   Comments: ____________________

3. Webbing

   a. Is the webbing cut, frayed, or worn excessively? ☐ Yes* ☐ No

   Comments: ____________________

4. Buckle and Latch Plate (Tongue)

   a. Does the buckle latch when the tongue is inserted? ☐ Yes ☐ No*

   Comments: ____________________

   b. Does buckle unlatch and release when button is depressed or lever raised? ☐ Yes ☐ No*

   Comments: ____________________

5. Adjustment Hardware

   a. Do length adjusting devices shorten and lengthen webbing properly and are they in good condition? ☐ Yes ☐ No

   Comments: ____________________

6. Retractors

   a. Does webbing extend and retract freely from fully stowed to fully extended positions? ☐ Yes ☐ No*

   Comments: ____________________

b. Does the retractor mechanism function properly? ☐ Yes ☐ No*

Comments: ____________________

7. Pelvic and Upper Torso Restraint (3-Point Seat Belt Assembly)

a. Does the D-ring which guides the webbing for the upper torso restraint pivot freely? ☐ Yes ☐ No

Comments: ____________________

b. Does the webbing extend and retract freely without excessive contact with obstructions? ☐ Yes ☐ No

Comments: ____________________

c. Does the comfort mechanism function properly? ☐ Yes ☐ No*

Comments: ____________________

8. Tether Belts/Cables

a. If adjustable, are tether belts or cables adjusted properly? ☐ Yes ☐ No

Comments: ____________________

b. Are tether belts or cables free from damage such as cuts, tears, abrasion, etc.? ☐ Yes ☐ No*

Comments: ____________________

* Items shown on the inspection checklist with an asterisk (*) are considered essential to the usage and proper functioning of the seat belt assembly in a collision. If these are not found to be acceptable, then the entire seat belt assembly should be replaced. Other items on the checklist having a negative should be corrected through maintenance procedures or contact with the vehicle manufacturer.

Inspected by: ____________________

Date: ____________________

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PARTS LIST

QTY.	PARTS/MATERIALS	PRICE
	TOTAL PARTS/MATERIALS	

SPECIFICATIONS CHECKED

School/Work Name ______

Address ______

Phone # ______

Date In ______

Date Out ______

JOB TICKET

Customer Name ______

Customer Address ______

Customer Phone # ______

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ______

Services/repairs made: ______

LABOR

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

______ Date ______

Technician ______

Supervisor ______

Unit Contents

Student Components

Student Page

Objective Sheet 2A-3

Information Sheet 2A-5

Job Sheets

1—Diagnose Unusual Tire Wear Patterns, Check Tire Pressure, and Measure and Match Tires 2A-31
2—Diagnose Tire/Wheel Vibration, Inspect Mounting Hardware and Check Tire/Wheel Runout and Balance 2A-35

Objective Sheet

Unit Objective

After completing this unit, the student should be able to diagnose tire, rim, and wheel problems and check runout and balance. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to tires, rims, and wheels with their definitions.
2. Distinguish among the functions of tires, rims, and wheels.
3. State materials used for tires, rims, and wheels.
4. Distinguish between types of tire construction.
5. Match types of tires with their correct descriptions.
6. Identify the parts of a radial tubeless tire.
7. List types of tire damage.
8. Identify radial tire wear conditions.
9. Complete statements concerning tire matching and mixing.
10. Distinguish among types of rims.
11. Complete statements concerning tire and rim sizes.
12. Distinguish between basic types of wheels.
13. Identify mounting hardware for wheels.
14. List types of rim and wheel damage.
15. Label wheel tightening sequences.
16. Complete statements concerning tire and wheel assembly runout and balancing.
17. Distinguish between correct and incorrect safety precautions to follow when servicing tires, rims, and wheels.
18. Complete statements concerning tire maintenance.
19. Diagnose unusual tire wear patterns, check tire pressure, and measure and match tires. (Job Sheet 1)
20. Diagnose tire/wheel vibration, inspect mounting hardware. and check tire/wheel runout and balance. (Job Sheet 2)

Information Sheet

Objective 1

Terms and definitions

a. **Aspect ratio**—Tire size designation that is the ratio of the tire's section height to section width for a specified rim width

b. **Bead chafing**—Wear of the bead against the rim

c. **Bead seating**—Positioning of the bead on the rim

d. **Capacity**—Maximum amount that a tire, rim, or wheel can carry or store; expressed in load (lbs) and cold inflation pressure (psi)

e. **Casing**—Tire structure excluding the tread and shoulder

f. **Circumferential direction**—360 degrees around the tire

g. **Delamination**—Separation of layers of rubber

h. **Demountable rim**—Rim intended for use on a cast spoke wheel

i. **Disc wheel**—Permanent assembly of a disc and a rim for attachment to vehicle hub

j. **Dual spacing**—Distance from the center of a tire to the center of the other tire in a dual tire arrangement

Note: Dual spacing is determined by adding two half dual spacings (disc wheels) or two rim offsets plus one spacer band width (spoke wheels).

k. **Grooves**—Spaces between two adjacent tread ribs or lugs

l. **Mounting**—Assembling the tire on the rim

Note: "Demounting" is the opposite of mounting.

m. **Out-of-balance**—Condition that exists when there is an unequal distribution of weight about the axis of rotation

n. **Pi (π) tape**—Measuring device used to obtain the circumference of a tire for comparing and matching tires

o. **Ply** (plies)—Layer(s) of rubber-coated parallel cords

p. **Radial direction**—From bead to bead

q. **Retread**—To apply and cure new tread on a casing to extend the life of the tire

r. **Rim clamp**—Device used to hold a demountable rim on a spoke wheel

s. **Rim well**—Dropped center area of a single-piece rim made to a smaller diameter than the bead seat area of the rim

t. **Rotating assembly**—All rotating parts including the hub, drum, wheel, rim, tire, and associated hardware

u. **Spacer band**—Metal band that separates two demountable rims on a rear spoke wheel

v. **Spoke wheel**—Casting with multiple spokes that provides a means of attaching a demountable rim to a vehicle

w. **Torque**—Measurement of nut tightness

x. **Trajectory**—Potential path or route that a component may travel during an accident such as the sudden release of pressurized air or explosion

y. **Valve hole**—Round hole in a single-piece rim that receives the valve stem

z. **Valve slot**—Elongated opening in a multipiece rim that receives the valve stem

aa. **Valve stem**—Protruding part of a tire tube that allows for inflation/deflation of the tube-type tire assembly when properly mounted

bb. **Weathering**—Fine hairline cracks in the sidewall surface of the tire caused by oxidation and other atmospheric conditions

Objective 2

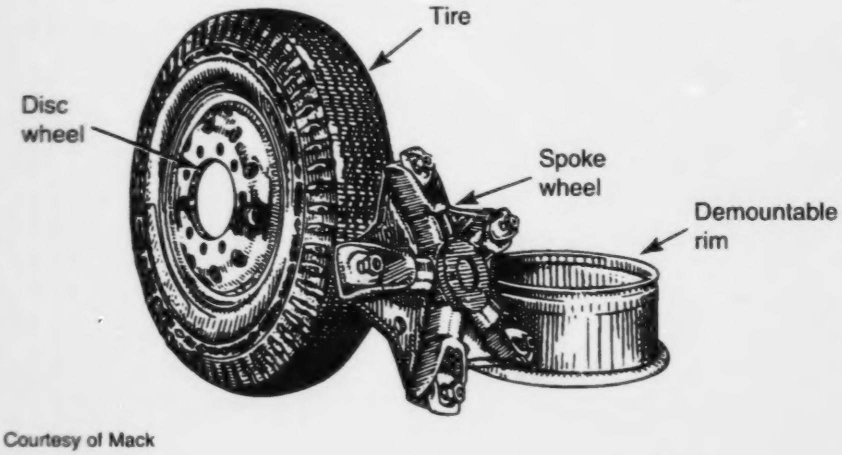
Functions of tires, rims, and wheels

a. **Tires**—Support the weight of the vehicle; transfer the load to the road

b. **Rims**—Support the tires and contain the tires' inflation pressures

c. **Wheels**—Transfer the load from the axle to the tires

Figure 1



Courtesy of Mack

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Objective 3

Materials used for tires, rims, and wheels

a. **Tires**—Rubber compounds including nylon, polyester, and other materials for casings and treads; steel for reinforcing plies and belts

b. **Rims**—Steel or aluminum

c. **Wheels**—Steel, cast iron, or aluminum

Objective 4

Types of tire construction

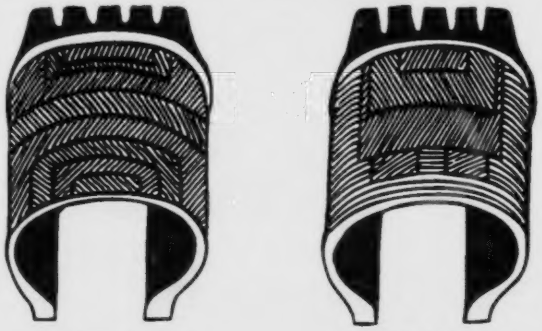
a. **Bias ply**

- The body plies overlap and cross on the diagonal from tire bead to tire bead
- Not commonly used on highways

b. **Radial ply**

- Body plies are laid at right angles to the circumference of the tire and run from bead to bead. The plies are then secured with belts that wrap around the tire's circumference.
- Commonly used and preferred over bias tires because they have less tread distortion, greater fuel efficiency, longer tread wear, and more puncture resistant. They also give the drive more steering control and traction, as well as a smoother ride.

Figure 2



Bias ply Radial ply

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Objective 5

Types of tires

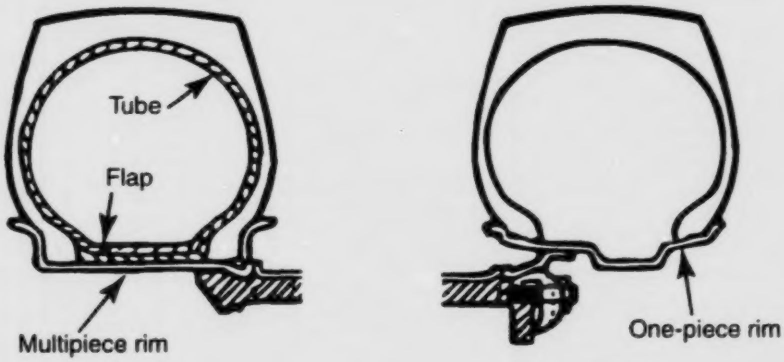
a. **Tube type**

- Uses a tube (inner tube) and flap to contain the pressurized air
- Requires a multipiece rim/wheel assembly and is therefore dangerous to mount/remount.
- Less commonly used than tubeless

b. **Tubeless**

- Uses a thin layer of air and moisture-resistant rubber inside the tubeless tire to obtain an internal seal of the casing
- Requires a one-piece rim which results in improved mounting safely.
- More commonly used because they offer several advantages—less weight, reduced parts inventory, improved durability because of less heat, and reduced downtime from punctures.

Figure 3



Tube type

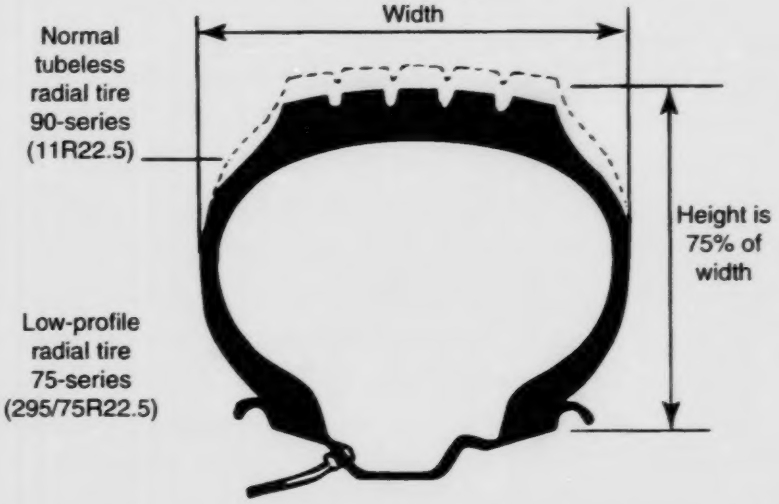
Tubeless

Courtesy of The Maintenance Council (TMC) of the American Trucking Associations. 800-ATA-LINE. Reprinted with permission.

c. **Low aspect** (or low profile)

- Special type of radial tubeless tire that features section width wider than section height. Typical ratio is 75% to 80% of conventional tires.
- Have shorter sidewall heights and wider tread widths than conventional tires
- Popular because of improved tread wear, lighter weight, and improved stability and handling

Figure 4


Width
Normal tubeless radial tire 90-series (11R22.5)
Height is 75% of width
Low-profile radial tire 75-series (295/75R22.5)

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d. **Wide base**

- Are larger tires and provide increased load capacity
- May be used instead of duals in some situations; called super singles

Objective 6

Parts of a radial tubeless tire

a. **Tread**—Part of the tire that contacts the road; designed to provide traction and wear; consists of lugs or ribs with grooves in between that can be measured for depth of tread

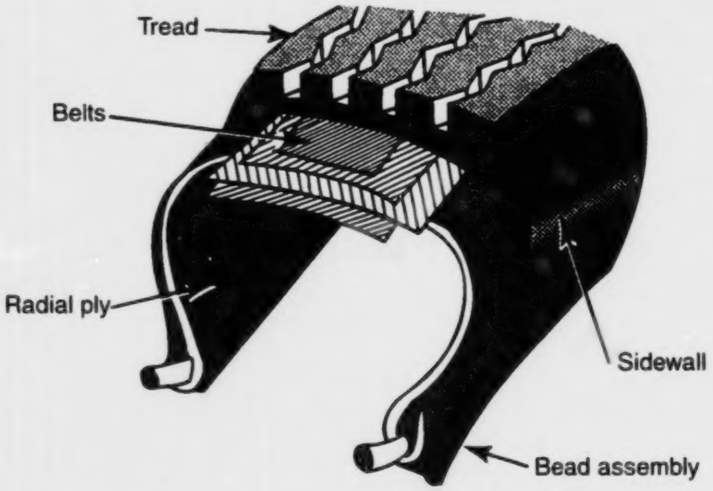
b. **Belts** (or belt plies)—Provide strength to the tire, stabilize the tread, and protect the air chamber from punctures; commonly made of steel

c. **Radial ply**—Transmits all load, braking, and steering forces between the wheel and the tire tread; works with the belt plies to contain the tire's air pressure

d. **Sidewall**—Outside casing that protects the radial ply; designed to withstand flexing and weathering

e. **Bead assembly**—Stiff area that secures the inflated tire against the rim

Figure 5



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Objective 7

Types of tire damage

a. Bead area

- Torn beads
- Kinked or distorted beads
- Deformed beads

b. Sidewall area

- Cuts and snags
- Sidewall separation
- Chain damage
- Weathering
- Impact breaks
- Petroleum product damage
- Blisters/bumps

c. Crown area (tread and shoulder)

- Penetrations and road hazards (nails, glass, etc.)
- Cuts and snags
- Belt lift/separation
- Tread lift/separation
- Brake skid damage
- Lug base cracking
- Impact breaks
- Chipping/flaking/chinking tread
- Excessive wear
- Groove cracking

d. Tire interior

- Penetrating objects
- Liner splice
- Liner bubbles or blisters
- Liner cracking
- Pulled/loose cords

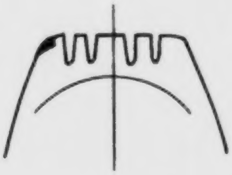
Information Sheet

Objective 8

Types of radial tire wear conditions and causes

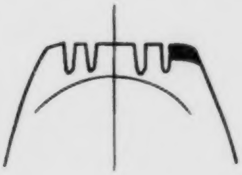
a. **Shoulder step/chamfer wear**—Typical in slow wearing operations

Figure 6



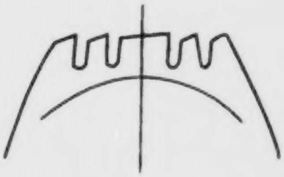
b. **Full shoulder wear, usually one side** — Improper toe condition, drive axle misalignment, or loose or worn wheel bearings

Figure 7



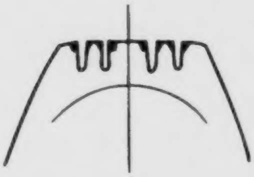
c. **Feather wear** — Severe misalignment such as excessive toe; drive axle misalignment; worn, missing, or damaged suspension parts; bent tie rod; or other chassis misalignment

Figure 8



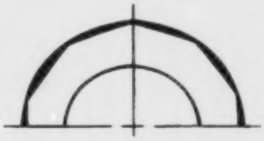
d. **Erosion/river/channel wear**—Typical of slow wear on free rolling axles, especially on light loads with frequent turning

Figure 9



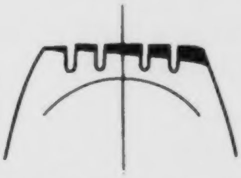
e. **Cupping/scallop wear**—Out of balance condition, improper rim/wheel mounting, or lack of shock absorber control on some suspension types

Figure 10



f. **One-sided wear**—Improper alignment, worn king pins, loose front wheel bearings, excessive axle loads; non-uniform tire and wheel assembly caused by improper bead seating or a bent wheel

Figure 11



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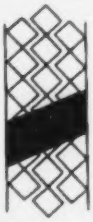
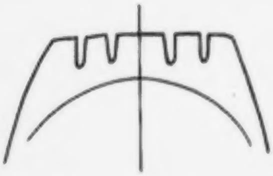
g. **Diagonal wear** — Runout and/or out of balance with a slow rate of wear

Figure 12



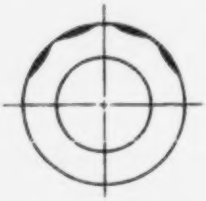
i. **Overall wear**—Heavy surface conditions such as mountainous terrain, frequent and severe turns, abrasive road surfaces, etc.

Figure 14



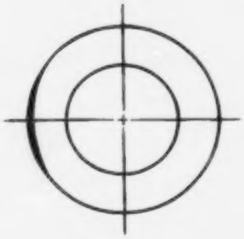
k. **Erratic depression wear**—Lack of shock absorber control, improper inflation pressure, loose or worn wheel bearings, improper bead seating, or out-of-balance condition

Figure 16



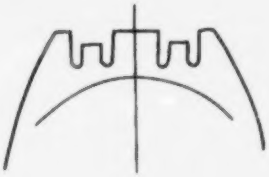
h. **Eccentric/out-of-round wear**—Excessive radial runout or other non-uniformity in the rotating assembly

Figure 13



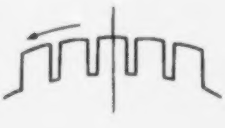
j. **Rib depression/punch wear**—Lack of shock absorber control, improper inflation pressure, loose or worn wheel bearings, improper bead seating, or out-of-balance condition

Figure 15



l. **Heal/toe wear**—Mismatched inflation pressures or tire diameters in a dual assembly

Figure 17



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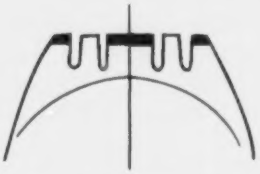
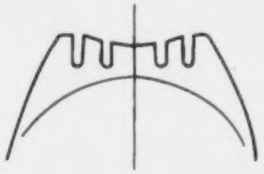
m. **Alternate wear**—Mismatched inflation pressures or tire diameters in a dual assembly

Figure 18



n. **Brake skid/flat spot wear**—New brakes, unbalanced brakes, aggressive use of brakes, and driver abuse

Figure 19



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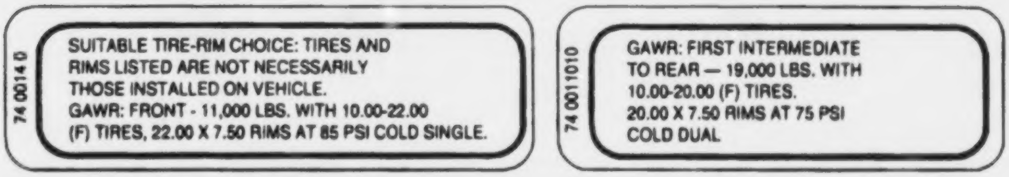
Objective 9

Tire matching and mixing

a. Do not change wheels or tires without checking the certified Gross Vehicle Weight Rating (GVWR). Tire and rim labels certify the minimum tire and rim combinations that can be installed.

Figure 20



74 00014 0

SUITABLE TIRE-RIM CHOICE: TIRES AND
RIMS LISTED ARE NOT NECESSARILY
THOSE INSTALLED ON VEHICLE.
GAWR: FRONT - 11,000 LBS. WITH 10.00-22.00
(F) TIRES, 22.00 X 7.50 RIMS AT 85 PSI COLD SINGLE.

74 0011010

GAWR: FIRST INTERMEDIATE
TO REAR — 19,000 LBS. WITH
10.00-20.00 (F) TIRES.
20.00 X 7.50 RIMS AT 75 PSI
COLD DUAL

Courtesy of Freightliner

Note: Labels shown are examples only. Actual specifications vary from vehicle to vehicle.

b. When pairing tires on a dual assembly, the tire diameters must not differ by more than 1/4 inch (6.4 mm), or the tire circumference by more than 3/4 inch (19 mm). The total tire circumference of one driving rear axle must match (as nearly as possible) the total tire circumference of the other driving axle.

Caution: Mismatching dual tires damages both the larger and smaller tire, as well as causing damage to the wheels. Blowouts can occur.

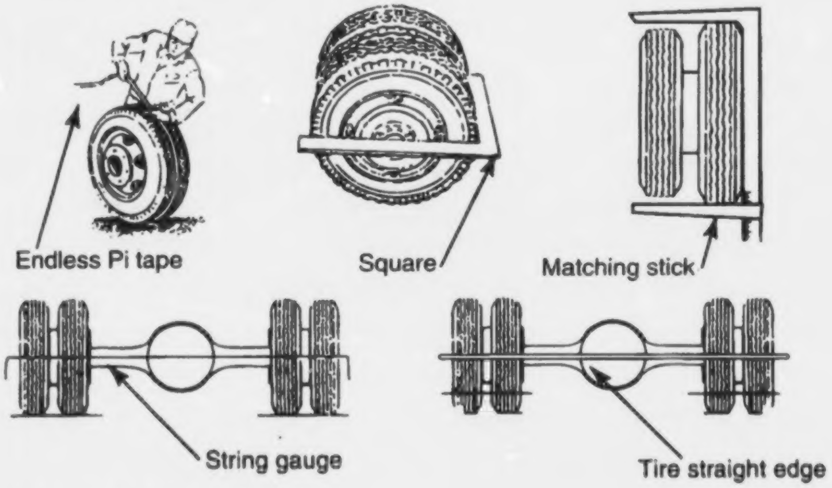
c. Better tire and vehicle performance is usually obtained by using tires of the same size and construction.

d. Using tires of different construction will result in loss of steering control and premature tire wear. However, it is permitted as an **emergency** measure if the following rules are observed:

- Do not mix radial and bias ply tires on the same axle.
- If both radial and bias ply tires are used, better handling is usually obtained by using the bias ply tires on the front axle.
- Use either all radial or all bias ply tires on the non-driving rear axles. However, all radial or all bias ply tires must be used on vehicles with tandem drive axles.

e. Tire diameter differences can be measured by using an endless pi tape, square, matching stick, string gauge, or tire straight edge.

Figure 21



Courtesy of Freightliner Corporation

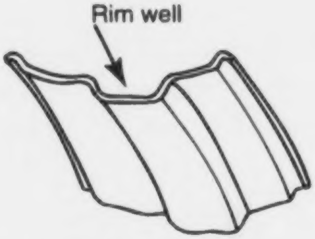
Objective 10

Types of rims

a. **Single-piece rim**

- Is a continuous one-piece assembly
- Dropped in center of rim base to allow for mounting
- Used for tubeless tires

Figure 22

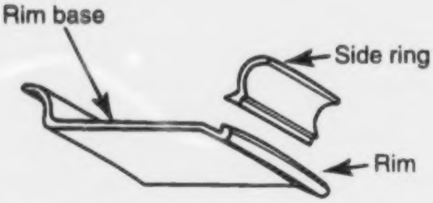


Courtesy of Goodyear

b. **Multipiece rim**

- Used on tube-type tires
- Are dangerous during demounting and mounting process because pieces can come apart with great force
- May be two-piece or three-piece
  - — Two-piece rim—Consists of a rim and a split side ring

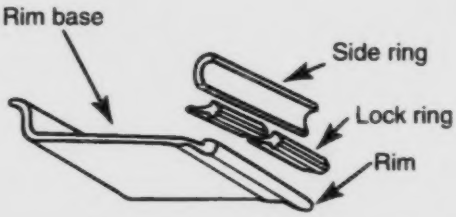
Figure 23



Courtesy of Goodyear

- Three-piece rim—Consists of a rim, continuous side ring, and a separate split lock ring

Figure 23


Rim base
Side ring
Lock ring
Rim

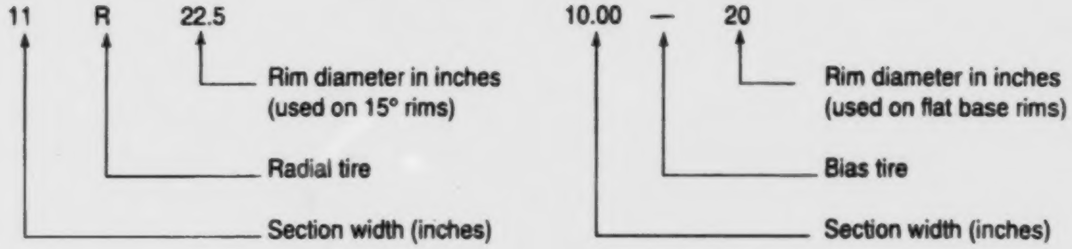
Courtesy of Goodyear

Objective 11

Tire and rim sizes

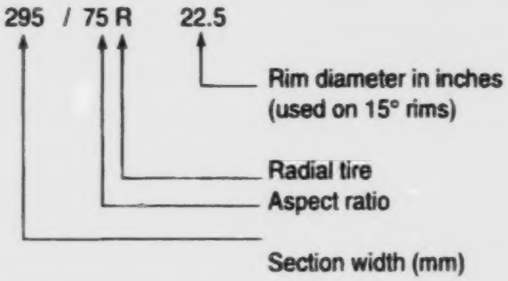
a. Standard tires are sized according to tire section width and rim diameter.

Figure 25—Standard aspect tire


11 R 22.5
Rim diameter in inches (used on 15° rims)
Radial tire
Section width (inches)
10.00 — 20
Rim diameter in inches (used on flat base rims)
Bias tire
Section width (inches)

b. Aspect ratio is also stated for low profile tires

Figure 26—Low profile tire


295 / 75 R 22.5
Rim diameter in inches (used on 15° rims)
Radial tire
Aspect ratio
Section width (mm)

c. The design rim width is approximately 75% of the tire width.

Example: An 11-22.5 tire uses an 8.25 rim. (11 x 0.75 = 8.25)

d. Most tire sizes have two or three approved alternative rim widths.

Table 1—Tire sizes and approved rims

Tire Size	Approved Rims	Tire Section Width
Tubeless 11-22.5	22.5 x 8.25 (Design)	11.00
	22.5 x 7.50	10.70
Tube-Type 10.00-20	20 x 8.0	11.15
	20 x 7.5 (Design)	10.95
	20 x 7.0	10.75

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e. Tire size is marked on the outside surface of the tire, along with the manufacturer's name, style name, and DOT code numbers (required by law) that identify manufacturing plant and date.

f. The Federal Motor Vehicle Safety Standard (FMVSS 120) requires that the rim size, type, and manufacturer's information must be stamped on the rim and rim components.

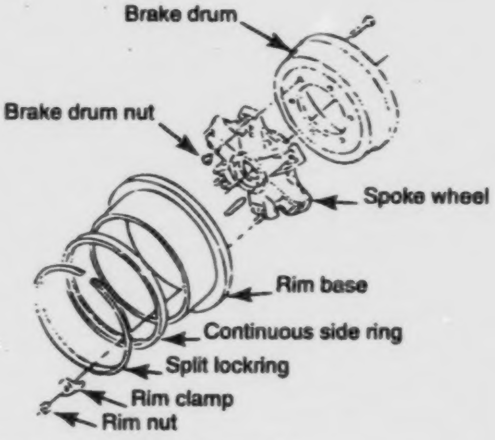
Objective 12

Cast spoke wheels

a. **Cast spoke wheels**

- Consist of a wheel and brake drum assembly installed on the axle and a tire and rim assembly that mounts on the wheel.
- Rim clamps and rim (hex) nuts hold the tire and rim assembly in place on the spoke wheel hub assembly.

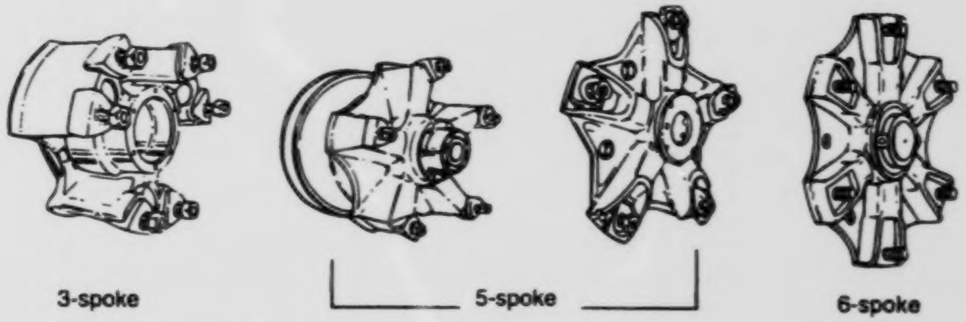
Figure 27



Courtesy of Freightliner Corporation

- Typical designs include 3, 5, and 6 cast spokes.

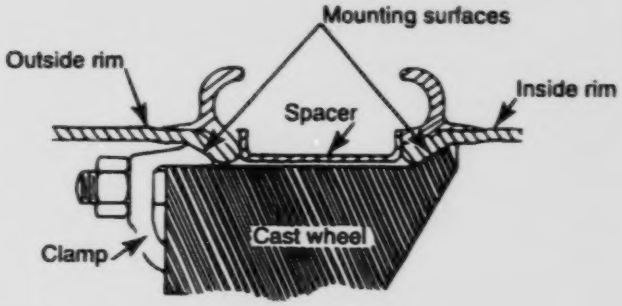
Figure 28


3-spoke
5-spoke
6-spoke

Courtesy of Freightliner Corporation

- Spacer bands (available in different widths) are used with duals on rear cast spoke wheels to hold the two rims apart and to provide proper dual spacing.

Figure 29

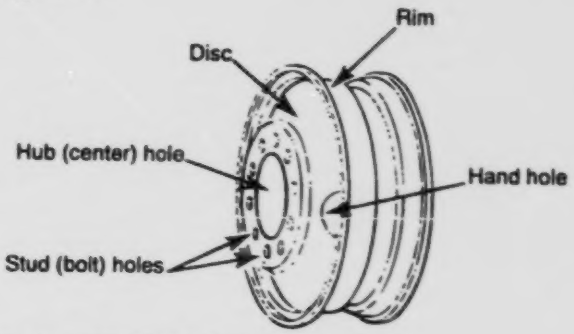

Mounting surfaces
Outside rim
Inside rim
Spacer
Clamp
Cast wheel

Courtesy of Peterbilt Motors Company/PACCAR Inc.

b. Disc wheels

- Consist of a rim and disc welded together.

Figure 30


Rim
Disc
Hub (center) hole
Hand hole
Stud (bolt) holes

Courtesy of Freightliner Corporation

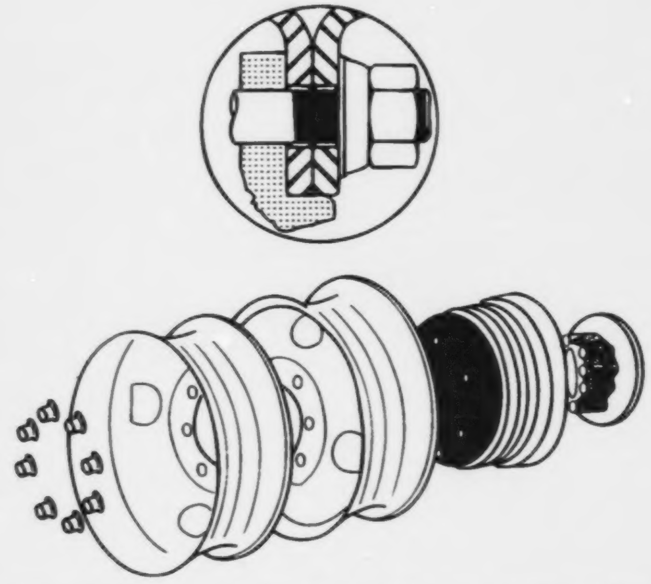
- After the tire is mounted on the rim/wheel, the assembly is held in place on the hub with wheel studs and nuts.
- There are two basic methods used for installing disc wheels—hub piloted and stud-piloted. Their components are not interchangeable.

— Hub-piloted disc wheels

(a) Location of wheel is accomplished by positing the wheel center hole on a machined pilot (continuous or interrupted) on the hub.

(b) Fastening is accomplished by flange nuts bearing against the flat face of the wheel disc.

Figure 31



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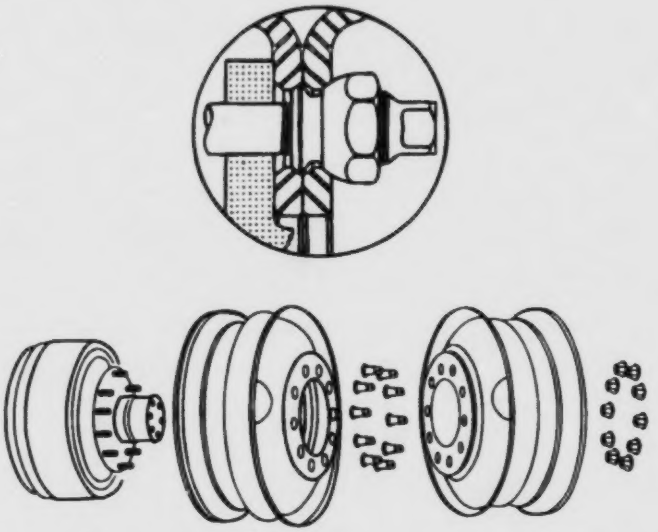
— Stud-piloted disc wheels

(a) Location and fastening of the wheel are both accomplished by spherical nuts which fit into corresponding chamber at each wheel both hole.

(b) Use double cap nuts that include inner cap nuts used to fasten inner wheels to a vehicle and outer cap nuts used to fasten single wheels and outer wheels to vehicle.

Figure 32



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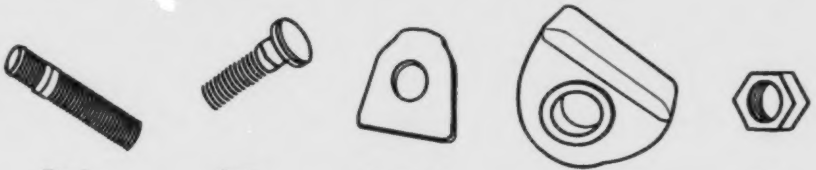
Objective 13

Mounting hardware for wheels

a. Cast spoke wheels

Figure 33—Rim clamps, studs,and nuts



Stud

Bolt (Special shaped head)

Front rim clamp

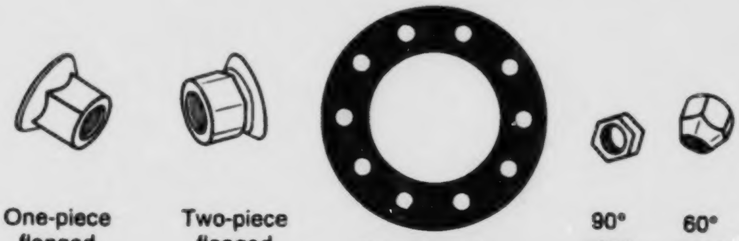
Rear rim clamp

Nut

b. Disc wheels

- Hub-piloted

Figure 34—Flanged nuts and cone nuts



One-piece flanged cap nut (light/medium truck)

Two-piece flanged cap nut (heavy-duty truck)

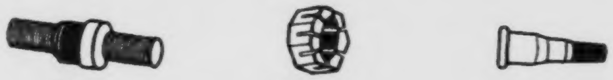
Clamping plate (light truck)

90° cone nut

60° cone nut

- Stud-piloted

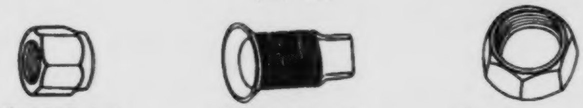
Figure 35—Studs and double cap nuts



Stud

Back or jam nut

Serrated bolt



Outer cap nut (for front)

Inner cap nut (for rear dual)

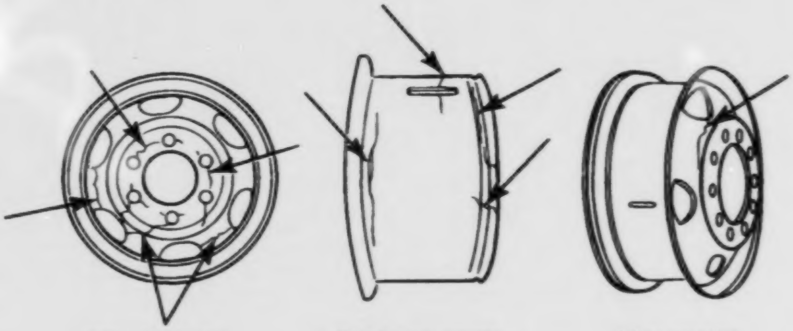
Outer cap nut (for rear dual)

Objective 14

Types of rim and wheel damage

a. Cracked rim, wheel, or disc

Figure 36



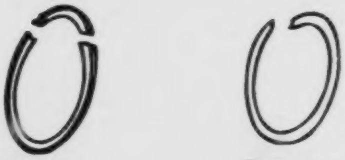
Wheel cracks

Rim base cracks

Disc cracks

b. Sprung or broken lock rings or side rings

Figure 37

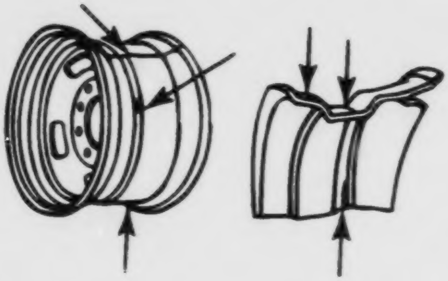


Broken

Sprung

c. Tubeless rim leaks

Figure 38



d. Corroded parts

e. Damaged inner or outer wheel cap nuts

f. Out-of-round wheel or rim (distortion)

g. Out-of-round or elongated stud holes on wheel

h. Cracked or bent valve cores

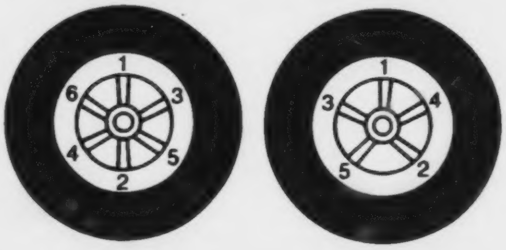
i. Damaged or worn clamps, rim spacer, rim studs, or spoke-wheel nuts

Objective 15

Wheel tightening sequences

a. Spoke wheels

Figure 39



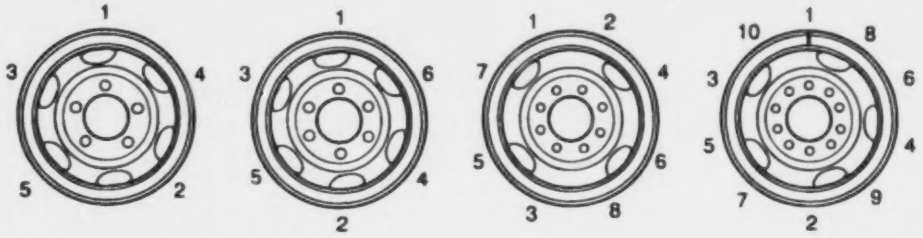
6-lug **5-lug**

Note: Uneven tightening will cause threads to protrude more on some studs and will result in uneven alignment.

b. Disc wheels

Note: Always tighten top nut first

Figure 40



Courtesy of Mack

Objective 16

Tire and wheel assembly runout and balancing

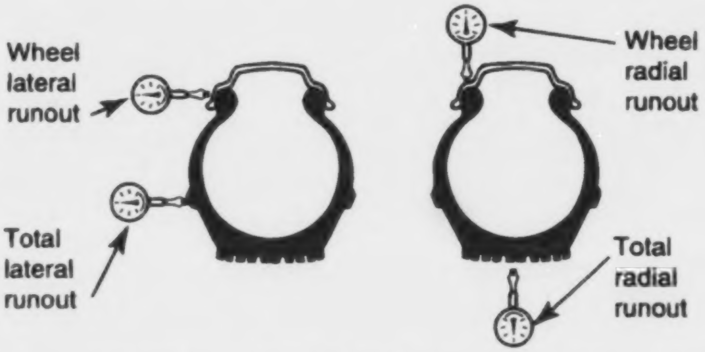
a. There are two types of runout—lateral and radial.

- Lateral runout—Variation in the rotating assembly in a side-to-side direction (wobble)
- Radial runout—Variation in the radius of the rotating assembly

b. A runout gauge is commonly used to check runout.

- Lateral runout should be checked on a smooth surface along the tire's upper sidewall.
- Radial runout should be checked on a smooth rib in the center of the tread.

Figure 41


Wheel lateral runout
Total lateral runout
Wheel radial runout
Total radial runout

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c. If runout exceeds suggested limits (see Table 2), check for bent rims, improperly adjusted wheel bearings, improper tire bead seating, tire flat spots, improperly tightened rim clamps, and rear rim spacers.

Table 2—Rotating Assembly Balance and Runout Limits

	Tire Positions	**Maximum Limits 20", 22", 22.5", 24.5"**
Rotating assembly static out of balance	Front (steering) Rear	40 in.-oz. 90 in.-oz.
Maximum correction wheel weights which can be added per rotating assembly	Front (steering) Rear	18 oz. 22 oz.
Lateral runout for rotating assembly	Front (steering) Rear	0.125 inches 0.187 inches
Radial runout for rotating assembly	Front (steering) Rear	0.125 inches 0.125 inches

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d. Correct excessive runout before checking tire/wheel assembly balance.

e. Out-of-balance rotating assemblies can contribute to driver discomfort because of excessive vibration, poor tire mileage, poor steering, mechanical failures, and irregular tire wear.

f. Rotating assemblies can be balanced in two ways—statically and dynamically. The goal of both is to obtain an on-center rotating wheel and assembly.

- Static balance—When the weight is equally distributed about the axis of rotation in such a manner that there is no tendency for the assembly to rotate by itself. Rotating assembly will remain at rest when stopped at any point in a rotation.

- Dynamic balance—When the weight is equally distributed about the axis of rotation in such a manner that the horizontal and vertical forces are constant during rotation. Rotating assembly is in balance when in motion. Weight is equally distributed around the perimeter of the tire as well as on both sides of the tire centerline.

g. If out-of-balance exceeds suggested limits (see Table 2), correct by adding weight to the rim or wheel flange, half on each side of the rim or wheel.

h. If a tire/wheel assembly is removed for balancing, be sure to mark the tire/wheel position on the brake drum or hub so it can be reinstalled in the same position.

Note: Tire balancing and other types of tire service are commonly performed in shops with special equipment and specially trained personnel because of the expense and hazards associated with tire service.

Objective 17

Safety precautions to follow when servicing tires, rims, and wheels

a. Although most school shops are not equipped for complete tire service, you should understand and follow all safety precautions and manufacturer's recommendations when working on or around tires, rims, and wheels.

> Caution: Inflated tires, multipiece rims, and damaged components are especially dangerous because they can explode with great force.

b. Never stand in front of or over an inflated tire. Stay out of the trajectory and warn others.

c. Block wheel on other side of vehicle before placing jack in position.

d. Always use a wood block under jack when working on the ground.

e. Do not add air to tire and rim assemblies that have been operated in a seriously underinflated or flat condition (80% or less of recommended pressure).

> Caution: Tires driven seriously underinflated or flat can be damaged as well as the rim components. Both the tire and the rim components can explode.

f. Always deflate the tire completely before removing from vehicle. Deflate both tires of a dual assembly. Remove valve core and exhaust all air pressure before removing the tire. Never attempt to unseat beads of an inflated tire.

g. Never attempt to lift or move heavy tire or wheels without help. Use a cable or chain sling if necessary.

h. Make sure that rim parts match properly. Rims and rim components from different manufacturers may look similar, but they are not interchangeable. Check identification stamping on rim and rim components to verify the match.

Examples: Correct size Goodyear size rings on matching Goodyear rim bases, correct size Firestone rings on matching Firestone bases

Caution: Mismatched tires and rims/wheels can explode during inflation or unseat later causing a vehicle accident.

i. Carefully remove rust, dirt, and other foreign materials from all rim surfaces and rim components to ensure safe, positive seating. This is especially important in the rim gutter and bead seat areas.

j. Check to make sure that the tire diameter matches the rim/wheel diameter.

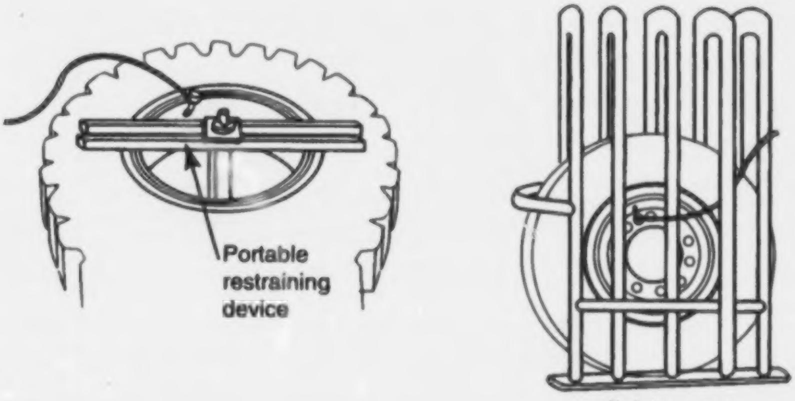
Caution: Mismatched tires and rims/wheels can explode during inflation or unseat later causing a vehicle accident.

k. Inspect all parts for damage and replace as needed.

l. Never attempt to rework, weld, heat, or braze rim or wheel parts.

m. Always use a restraining device or cage, clip-on air chuck, and remove valve/gauge when inflating a tire.

Figure 42



Safety cage

Courtesy of Mack

n. Never exceed maximum load or inflation pressures. If given tires and rim/wheels have different capacity limits (load and inflation), use the lesser limit.

o. Always check for proper seating of the bead before removing tire/rim from restraining device.

p. Never attempt to correct the seating by hammering, striking, or forcing parts while the tire is inflated.

q. Tighten stud nuts in the correct sequence, and torque to manufacturer's specifications.

Objective 18

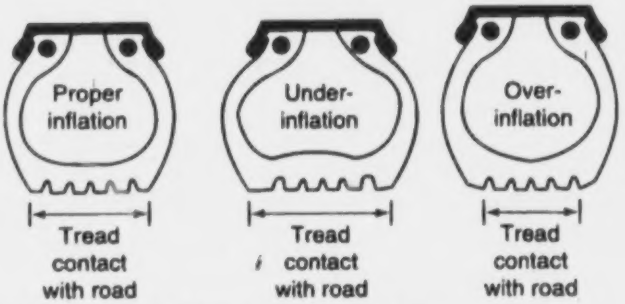
Tire maintenance

a. The most important factor in tire maintenance is proper inflation. Driving on tires with incorrect pressure is the most common cause of tire damage.

b. Check inflation pressures regularly using an accurate tire gauge. Refer to tire sidewall or tire inflation charts for proper inflation pressure.

- **Proper inflation**—Allows the tread to make full contact with the road for best traction, braking ability, and safety.
- **Underinflation**—Causes abnormal tire deflection which builds up heat and causes irregular wear.
- **Overinflation**—Causes tire to run hard, is more vulnerable to impacts, and causes irregular wear.

Figure 43



Courtesy of Peterbilt Motors Company/PACCAR Inc.

c. Keep both tires in a dual assembly at the same pressure. Unequal pressures can damage both tires, as well as the wheel bearings and other wheel components.

d. If significant low pressure is found, check tire for punctures, valve leakage, or wheel/rim damage.

e. Check tire tread depth periodically. Federal law requires truck tires on front axles to have at least 1/8″ tread depth. All other tires must have tread depth of at least 1/16″,

f. Keep all petroleum products (grease, lube oils, fuel) away from tires. Petroleum products can cause rubber to become soft and spongy.

Objective 19

Job Sheet 1—Diagnose Unusual Tire Wear Patterns, Check Tire Pressure, and Measure and Match Tires

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Correct procedures identified for assigned vehicle	______
• Procedures completed correctly	______
• Proper tools used correctly	______
• Safety precautions observed	______
• Installed equipment functions correctly	______
• Installed equipment meets specifications	______
• Clean-up and follow-up actions adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Truck-tractor to be checked
- Tire pressure gauge
- Tire tread depth gauge
- Clip-on air chuck
- Jack and safety stands
- Device for checking tire match (pi tape, matching stick, square, etc.)
- Hand tools

Guidelines

- To get maximum tread life from tires and reduce tire costs/mile, it is essential to minimize uneven tread wear and possible casing damage.

- Wear patterns are not as evident in short haul, high torque operations since the tread wears away much faster and unusual wear patterns are often literally scrubbed off.

- Inadequate tire inflation is a continuous cause of tire problems that is often overlooked, while misalignment is probably the least understood and often the last to be corrected.

- Mismatching dual tires overloads the larger diameter tire, causing it to overdeflect and overheat. The smaller diameter tire, lacking proper road contact, wears faster and unevenly. Tread or ply separation, tire body breaks, and blowouts can occur from mismatched duals.

Job Sheet 1

Procedure

☐ 1. Locate and follow the appropriate procedure in a tire service manual. These manuals have detailed pictures that will be very helpful with tire wear analysis.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Set parking brake, remove ignition key, and chock wheels on vehicle.

Note: Make sure you are in a well-lighted area.

☐ 4. Raise vehicle and place safety stand under axles. This will allow you to rotate the tires and release parking brake when needed.

☐ 5. Locate tire air pressure specifications and record on job ticket. Check side of tire for this information.

☐ 6. Remove cap from valve stem and check tire pressure with pressure gauge and record on job ticket.

☐ 7. If tire pressure is low, CHECK with instructor before inflating tire. Follow all safety procedures in tire service manual. Use a clip-on type air chuck with a remote valve so you can stand clear while inflating tire.

> Caution: Never reinflate or add inflation pressure to a tire that has been run flat or seriously underinflated.

☐ 8. After making sure that tire pressure is equal, measure tires on duals with a flexible pi tape, square, or tire straightedge, checking for tire match.

☐ 9. Inspect tire tread for unusual wear patterns. Use a tread depth gauge if needed. Common unusual wear patterns include the following:

a. Shoulder step chamfer
b. Feather wear
c. Cupping/scallop
d. Eccentric/out-of-round
e. Rib depression wear
f. Alternate lug wear
g. Full shoulder
h. Erosion/river/channel
i. One-side wear
j. Overall fast wear
k. Heel/toe wear
l. Brake skid/flat spot wear

☐ 10. Is unusual wear is located, refer to the tire service manual to identify probable cause and report needed repairs or adjustments on job ticket. Common causes of tire wear patterns include the following:

- Misalignment on steer, drive, trailer, and dolly axles
- Improper inflation maintenance
- Mismatching of tires, especially in dual applications
- Incorrect mounting of tire on the rim
- Non-uniformity of the rotating assembly—tire, wheel, brake drum, hub
- Excessive imbalance and/or runout
- Poorly maintained suspensions

Note: Depending on severity of wear, tires may need to be rotated. Check with instructor for directions and approval.

☐ 11. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ______

Address ______

Phone # ______

Date In ______

Date Out ______

JOB TICKET

Customer Name ______

Customer Address ______

Customer Phone # ______

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ______

Services/repairs made: ______

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

______ Date ______

Technician ______

Supervisor ______

Objective 20

Job Sheet 2—Diagnose Tire/Wheel Vibration, Inspect Mounting Hardware, and Check Tire/Wheel Runout and Balance

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Correct procedures identified for assigned vehicle	______
• Procedures completed correctly	______
• Proper tools used correctly	______
• Safety precautions observed	______
• Installed equipment functions correctly	______
• Installed equipment meets specifications	______
• Clean-up and follow-up actions adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Truck-tractor to be checked
- Air impact wrench
- Jack and safety stands
- Heavy wooden block
- Piece of chalk
- Tire gauge
- Device for checking tire match (pi tape, measuring stick, etc.)
- Torque wrench
- Wheel balance machine
- Balance weight
- Hand tools

Guidelines

- Vibration may be caused by a rotating assembly that is out-of-round or out-of-balance. First, we'll check out-of-round (runout). Other causes may be axle alignment or installation problems.

- A rotating assembly can be balanced in two ways, statically and dynamically. Static out-of-balance causes the assembly to bounce and dynamic out-of-balance causes the assembly to wobble.

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Talk to the driver to find out as much information as possible about the vibration complaint such as:

- Is it a recent problem or one that has existed for a long time?
- Are there any unusual vehicle handling characteristics that accompany the vibration?
- At what speed and engine RPM does the vibration occur?
- Is the problem observed when the transmission is in neutral and the vehicle coasting?

☐ 4. Take a road test with the driver, if possible, to understand the complaint. Try to identify the offending wheel position. Where is the vibration felt the most? If it is in the steering wheel, chances are it is a front tire problem. If the vibration is felt in the seat, the problem is usually a rear tire.

☐ 5. After road test, set parking brake, remove ignition key, and chock wheels on vehicle.

☐ 6. Raise vehicle and place safety stand under axles.

☐ 7. Inspect wheel/rim for cracks, bends, or distortion.

☐ 8. Check tires for proper inflation, impact cuts, bulges, breaks, cupping, flat spotting, poor recapping, and concentric bead seating on the rim.

☐ 9. Check to see if tires are matched on same axle.

☐ 10. Check for proper wheel lug nut torque. Follow the appropriate procedure in the service manual for tightening and torque specification of the lug nuts.

☐ 11. Check spoke wheel runout after the final torque has been applied to wheel stud nuts. The check requires a heavy wooden block and a piece of chalk. Position the block on the floor approximately 0.5 inches from tire and rotate the wheel slowly and observe the amount of runout. If runout exceeds 0.12, loosen and retorque stud nuts.

☐ 12. After completing tire/wheel assemblies check, if the vibration source has not been determined and corrected, proceed to check tire/wheel for out-of-balance machine service manual. Procedures vary between manufacturers. Check both static and dynamic balance.

- When a rotating assembly is in static balance, it remains at rest when stopped at any point in a rotation. The static out-of-balance condition is corrected by adding weight to the rim or wheel flange. Add half the weight of each side of the rim or wheel.
- Dynamic balance means balance in motion. As the assembly rotates, weight not only must be equally distributed around the perimeter but also equally distributed on both sides of the tire centerline.

☐ 13. If rebalancing is necessary, remove the old weights from the wheel prior to balancing the assembly. Be sure to mark the tire/wheel position on the brake drum or hub so it can be reinstalled in the same position.

☐ 14. Balance the steering tires first and then determine if the vibration problem has been corrected.

☐ 15. Record your findings on the job ticket and report any needed repairs on job ticket.

☐ 16. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____________________

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________________

Address ____________________

Phone # ____________________

Date In ____________

Date Out ____________

JOB TICKET

Customer Name ____________________

Customer Address ____________________

Customer Phone # ____________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________________

Services/repairs made: ____________________

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________________ Date ____________

Technician ____________

Supervisor ____________

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Unit Contents

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Unit 3-A Chassis Components

Objective Sheet

Unit Objective

After completing this unit, the student should be able to inspect chassis components and perform basic service on chassis components. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to chassis components with their definitions.
2. Select from a list the basic chassis components.
3. Complete statements concerning the parts of a frame assembly.
4. Select true statements concerning frame construction.
5. Complete statements concerning frame reinforcements.
6. List common procedures performed on frames.
7. Complete statements concerning guidelines for working on frames.
8. List things to check on frames.
9. Select true statements concerning frame fasteners.
10. List causes of stress leading to frame damage.
11. Distinguish between correct and incorrect practices to follow in frame repairs.
12. Complete statements concerning the basic procedure for checking alignment.
13. State the purpose of a fifth wheel.
14. Identify the basic types of fifth wheel mounting plates.
15. Name the basic types of fifth wheel locking mechanisms.
16. Identify the main components of a typical fifth wheel.
17. Match parts of a trailer with their correct functions.
18. Inspect and install or repair frame, hangers, brackets, and cross members. (Job Sheet 1)
19. Check and inspect vehicle frame alignment. (Job Sheet 2)

20. Inspect and service fifth wheel assemblies, pintle hitch, kingpin, and trailer plate. (Job Sheet 3)

21. Couple and uncouple fifth wheel. (Job Sheet 4)

Information Sheet

Objective 1

Terms and definitions

a. **Body-bound bolt**—Type of bolt with a special shoulder that fits tightly in the drilled/reamed bolt hole to prevent movement of mating parts

b. **Channel**—Inside C-shaped area on a frame rail

c. **Chassis**—Supporting frame of a vehicle; everything below the cab

d. **Couple/uncouple**—To join/disconnect the truck-tractor to/from the trailer

e. **Fifth wheel**—Coupling mechanism on the tractor that joins the tractor to the trailer

f. **Flange**—Projecting rib or rim of an object (such as a frame rail) used for strength and for attachment to another object

g. **Frame stations**—Locations or positions on a frame assigned by the manufacturer as reference points for measurement purposes

h. **Huck rivet**—Type of fastener in which nut is crimped to cap screw; cannot be removed with conventional tools

i. **Kingpin**—Pin on the trailer that connects to the tractor's fifth wheel

j. **Pintle hitch**—Coupling mechanism that joins two trailers together

k. **Running gear**—Combined parts of a trailer that allow it to be pulled down the road

l. **Web**—Plate connecting upper and lower flanges on a frame rail

m. **Yield strength**—Maximum stress that a material will withstand before it is permanently bent or twisted out of shape

Note: The higher the number, the stronger the material.

Objective 2

Basic chassis components

a. Frame assembly including rails, cross members, brackets, and hangers

b. Fifth wheel

c. Suspension components (such as leaf springs, air springs, pads, etc.)

d. Axles

- Front axle
- Bogie—Rear axles and springs

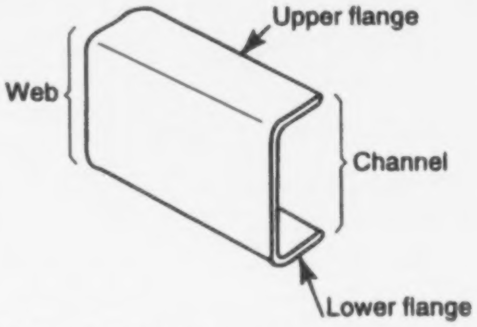
Objective 3

Parts of a frame assembly

a. Frame rails

- A typical frame has two rails.
- Rails are designed to carry the load.
- Each rail consists of an upper flange, a lower flange, a web, and a channel.

Figure 1



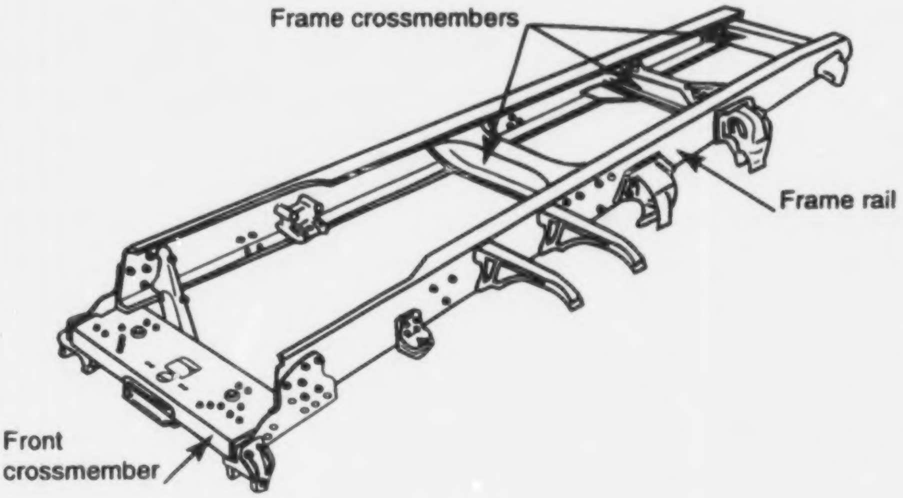
Courtesy of Freightliner Corporation

b. Cross members

- There are usually four to six cross members located between the rails.
- Their primary purposes are to stabilize and secure the rails and to support vehicle components such as radiator, engine, and cab.
- Cross members also serve as mounting pads for accessories such as air tanks and fuel tanks. Special rubber cushion supports are used to help reduce road shocks.
- Cross members may also be used to protect wires or tubing routed from one side of the vehicle to the other.

Note: The frame assembly is supported on the front and rear axles.

Figure 2



Courtesy of Freightliner Corporation

Objective 4

Frame construction

a. There are three basic design styles of frames—standard, dropped, and unequal offset.

- A standard frame has straight, parallel rails.
- A dropped frame has rails that are flared and dropped. This drop allows for a lower center of gravity, better vehicle stability, improved serviceability, and more room for larger engines and larger radiators.
- An unequal offset frame has rails that unequally offset from the vehicle centerline.

b. Frame rails may be made of aluminum, carbon steel, or steel alloy. Each of these frame materials is manufactured to a different yield strength.

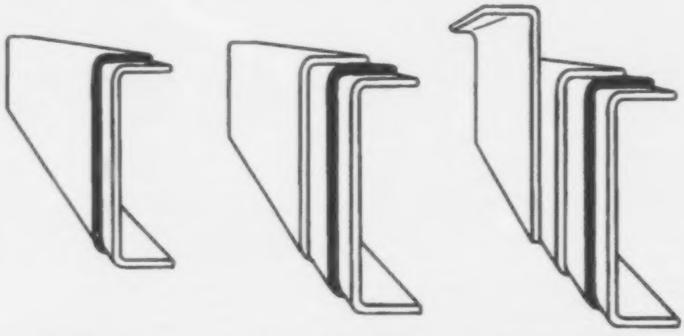
- The yield strength of aluminum ranges from 40,000 to 60,000 psi.
- The yield strength of carbon steel frames varies from 36,000 to 80,000 psi.
- The yield strength of steel alloy ranges from 80,000 to 110,000 psi.

Objective 5

Frame reinforcements

a. Frame rail reinforcements are used to increase the resistance to bending and twisting forces and to increase the load-carrying capacity. Manufacturers often reinforce frames with additional layers of metal.

Figure 3



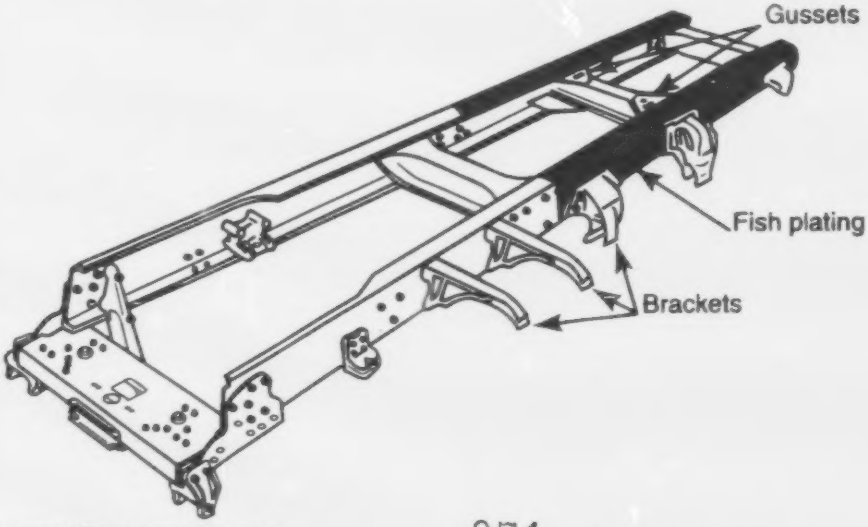
Two-element Three-element Four-element

Courtesy of Mack

b. Other reinforcements may be added later. These include fish plating, gussets, and brackets.

- Fish plating—Consists of bolting a steel plate to the outside of rails. It is applied to a standard frame when a vehicle must carry a load greater than the design allows, or when the vehicle has to operate on rough terrain.
- Gussets and brackets—Steel plates or angle iron reinforcements bolted or riveted to the rails for additional strength.

Figure 4



Courtesy of Freightliner Corporation

Objective 6

Common procedures performed on frames

a. Adding attachments such as fuel tank brackets, air tank, etc.

b. Lengthening frame

c. Reinforcing (strengthening) frame

d. Repairing cracks in rails and/or cross members

e. Removing/replacing/adding cross members

f. Straightening frame

g. Checking frame alignment

Objective 7

Guidelines for working on frames

a. When lifting or moving frame rails, use special care so you do not cut, scratch, or damage the exposed frame assembly.

  - Cushion all chains and cables with a section of heavy hose or use a rubber lifting strap when hoisting.
  - Place a block of wood between the jack and the frame when raising with a jack.

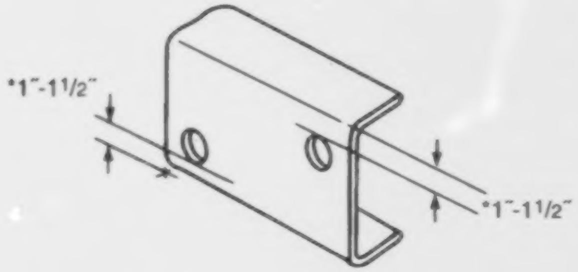
b. Never heat the frame rails for straightening purposes. This could result in structural failure of the rail. If the frame must be straightened, all work must be done cold. Frame rails that are severely damaged should be replaced.

c. Drilling holes

  - Avoid drilling when possible. Use existing holes placed by the factory.
  - When necessary, holes may be drilled in the web area only. Do not drill on the flanges.
  - Do not drill holes beyond the central one-third of the web area.
  - Do not drill any holes larger than the existing cross member or spring bracket bolt holes made by the manufacturer.
  - Do not drill holes any closer to the frame flanges than the present bolt pattern used by the manufacturer.

- On aluminum frame rails, the edge (not the center) of the drilled hole must be no closer than 1½" (38 mm) from the outer face of the flange. On steel frame rails, the edge (not the center) of the hole must be no closer than 1" (25 mm) from the outer face of the flange.

Figure 5

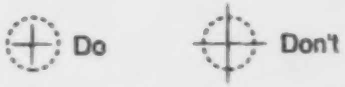


*1 1/2" (38 mm) for aluminum rails
1" (25 mm) for steel rails

Courtesy of Freightliner Corporation

- Do not drill more than two holes on a vertical line.
- Do not drill holes too close together. Failure can occur across a line of holes.
- If possible, use a lead pencil or soapstone for marking the location of holes to be drilled. You will be able to see the pencil lines more clearly if you will chalk the surface of the rail first.
- If a scribe must be used, make a very small mark. The entire scribe mark must lie within the circumference of the drilled hole. A crack may start on any scribe mark that extends beyond the hole. This is especially important on aluminum frames.

Figure 6



Courtesy of Peterbilt Motors Company/PACCAR Inc.

d. Bolting

- Clean both surfaces before bolting together. Remove all dirt and corrosion.
- Use bolts that fit freely in the holes. Do not force into place.

- Whenever unlike metals are fastened together, such as aluminum rails and steel cross members, special steps must be taken to prevent corrosion of the aluminum. Aluminum surfaces must be painted or another surface covering, such as Alumalastic®, Grafo®, or equivalent, must be applied to mating surfaces.
- Fill empty bolt holes (unused holes) with extra bolts and nuts.

e. Welding/cutting

- Follow all shop safety rules when welding and cutting such as wearing approved masks/shields and gloves and operating only in approved areas.
- Disconnect the ground cable from the truck's battery before welding or cutting to prevent damage to electrical and electronic components.
- Clamp the welding ground lead directly to the frame as close as possible to the welded area and never to rotating components. Bearings and other parts will be damaged if current must pass through them in order to complete the circuit.
- Use the welding rod and size recommended for the type of rail material (aluminum, steel, etc.), and follow the suggested current and voltage specifications.
- Use the welding/cutting method recommended by the frame manufacturer. Gas-metal arc welding (GMAW), shielded-metal arc welding (SMAW), and gas tungsten arc welding (GTAW) are commonly recommended. Refer to the welding equipment manufacturer for appropriate settings.
- Do not weld attachments directly to the frame rail. Bolting and clamping are preferred attachment methods. To avoid direct welding, equipment brackets should be welded on a separate reinforcement, and then the reinforcements should be bolted to the rail.
- Do not weld into the radius of the flange or along the edge of the flange.

Objective 8

Things to check on frames

a. Loose or missing bolts or rivets

b. Cracks in side rails, cross members, and brackets

c. Elongated holes in side rails, cross members, and brackets

d. Distortion and lack of alignment

Objective 9

Frame fasteners

a. Components may be fastened to the frame using **rivets** or **bolts**.

b. The goal of both methods of fastening is "to prevent movement between mating parts."

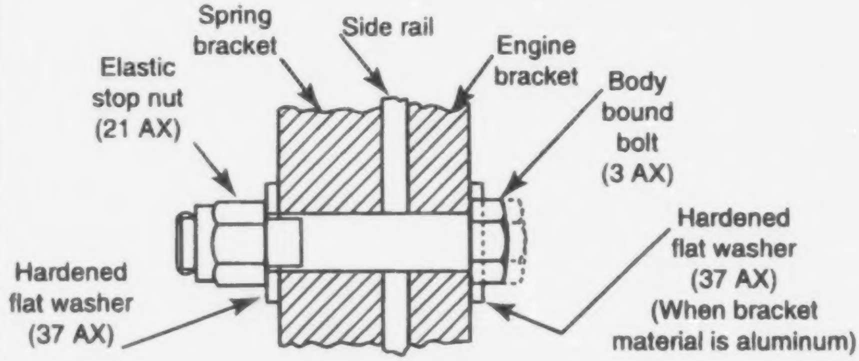
c. Two types of rivets are commonly used for frame fastening.

- Standard cold rivets
- Huck rivets

d. Bolting

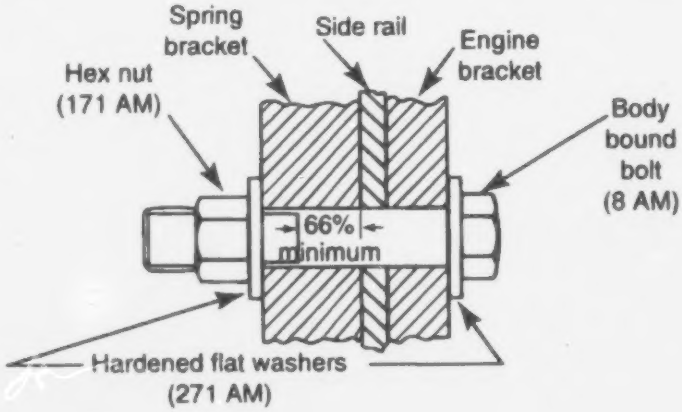
- Special SAE or metric body-bound bolts are used to prevent parts from bearing on the threaded portion of the bolt.

Figure 7—Recommended SAE body-bound bolt installation


Spring bracket
Side rail
Engine bracket
Elastic stop nut (21 AX)
Body bound bolt (3 AX)
Hardened flat washer (37 AX)
Hardened flat washer (37 AX) (When bracket material is aluminum)

Courtesy of Mack

Figure 8—Recommended metric body-bound bolt installation


Spring bracket
Side rail
Engine bracket
Hex nut (171 AM)
Body bound bolt (8 AM)
66% minimum
Hardened flat washers (271 AM)

Courtesy of Mack

- To select the proper body-bound bolt length, measure the number of parts to be assembled together to determine the accumulated thickness. This will then be used to determine the proper body length and overall bolt length.

- A hardened steel flat washer must be used under each nut (both SAE and metric). When the rail is aluminum, two steel washers are used, one on each side of the rail.

Objective 10

Causes of stress leading to frame damage

a. Incorrect bolting patterns

b. Notches

c. Improper load concentrations, including overloading and uneven loading

d. Loose bolts

e. Abrupt change in section

f. Operating vehicle on extremely rough terrain

g. Rail flanges that have been welded or drilled with holes

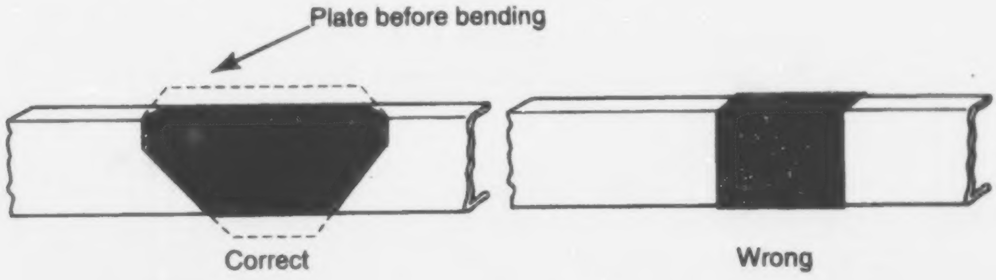
Objective 11

Practices to follow in frame repairs

a. Identify the source of stress that caused the original frame damage. When making repairs, do not create new stress concentrations.

b. Use reinforcement plates that are long enough to extend beyond the critical area so that the ends can be cut on an angle instead of square across the frame section.

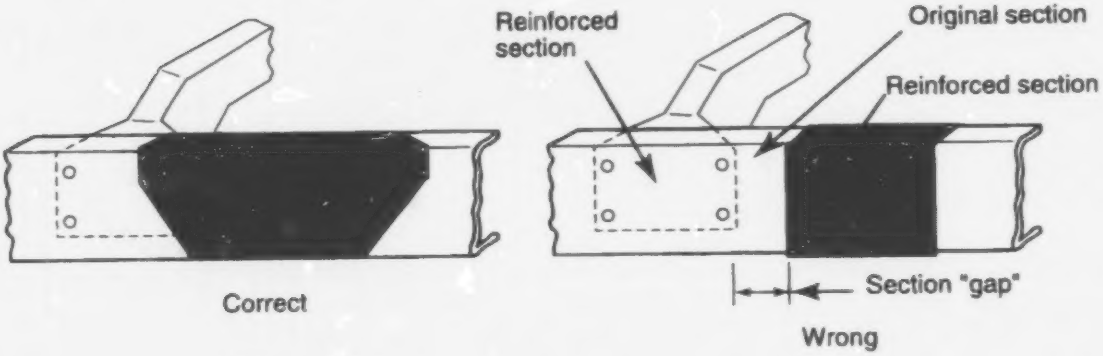
Figure 9—Reinforcement plate size



Courtesy of Mack

c. Avoid section gaps caused by the reinforcement plates stopping short of ends of adjacent cross member gussets or brackets.

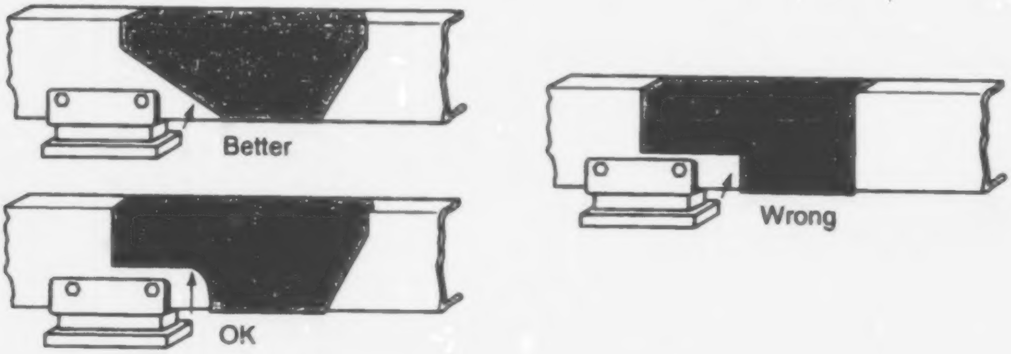
Figure 10—Reinforcement plate location


Reinforced section
Original section
Reinforced section
Section "gap"
Correct
Wrong

Courtesy of Mack

d. Never leave a sharp internal angle when cutting reinforcement plates or when modifying structural members.

Figure 11—Reinforcement plate angle


Better
OK
Wrong

Courtesy of Mack

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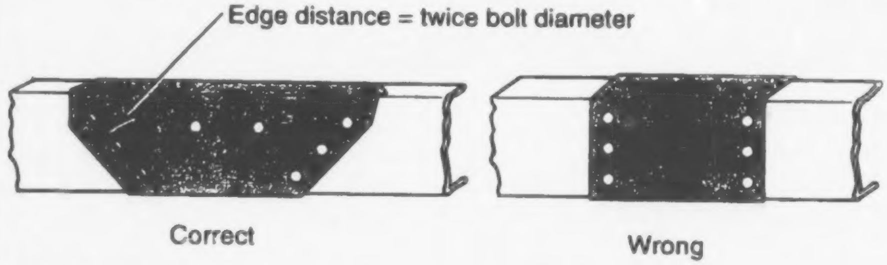
e. Avoid several holes in direct vertical alignment or holes too close together. A staggered bolt pattern with good spacing and sufficient edge distance is desirable.

Figure 12—Reinforcement plate bolt spacing



Courtesy of Mack

f. Remove all cracks, nicks, and burrs from the edges of reinforcement plates by grinding.

g. Weld all small cracks. Parts with large cracks should be replaced.

h. Repair enlarged holes by reaming to accept the next larger bolt diameter. For critical areas, body-bound bolts with hardened washers should be used.

Objective 12

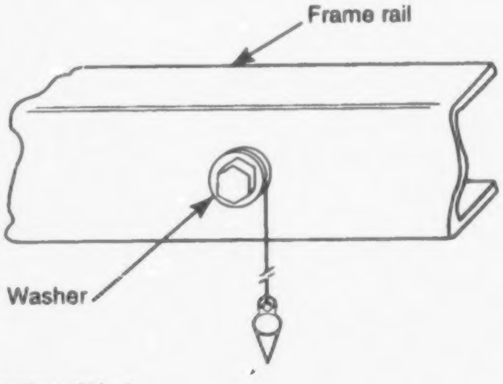
Basic procedure for checking alignment

a. Check alignment by transferring vehicle reference points to a level floor with a plumb bob.

b. Locate reference points at the same positions on both sides of the vehicle.

c. Hang the plumb bob string through the trunnion and wheel hub centerlines and over the front of the washer at specified frame rail bolt locations. Do not run the plumb bob over the nut. If the washer is missing, remove the bolt and install the correct size washer.

Figure 13

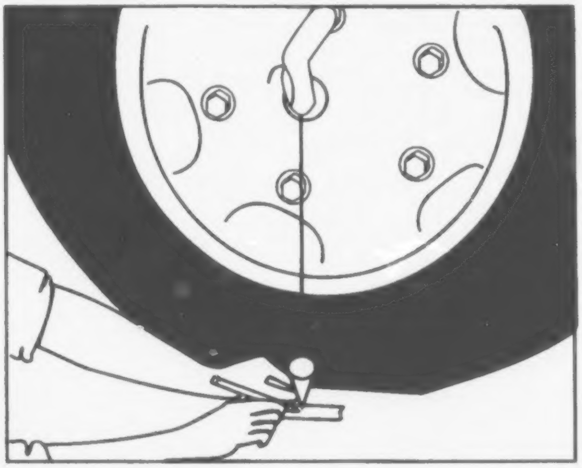


Courtesy of Mack

d. Use the exact same bolt on each rail.

e. Place a piece of masking tape under the plumb bob and accurately mark the location with a pencil.

Figure 14



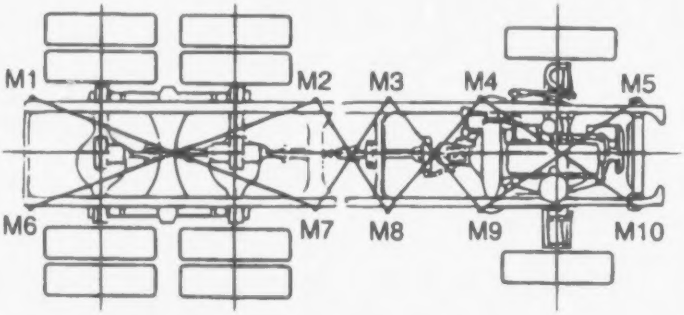
Courtesy of Mack

f. Continue marking reference points at all designated positions.

g. Move the vehicle out of the way of the points marked on the floor.

h. Snap a chalk line to connect the points in a crisscross pattern.

Figure 15



Courtesy of Mack

i. Measure lines and compare measurements to check frame for squareness.

Example: $M_1M_7 = M_2M_6$, $M_2M_8 = M_3M_7$, $M_4M_{10} = M_5M_9$

Objective 13

Purposes of a fifth wheel

a. To connect the tractor (power unit) to the trailer (payload/cargo)

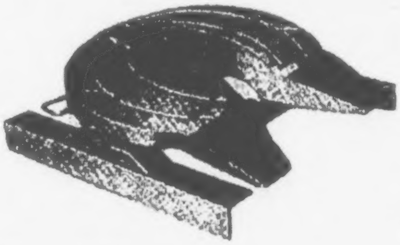
b. To allow pivoting between the tractor and the trailer for turning corners or reversing

Objective 14

Basic types of fifth wheel mounting plates

a. Stationary mounting plate

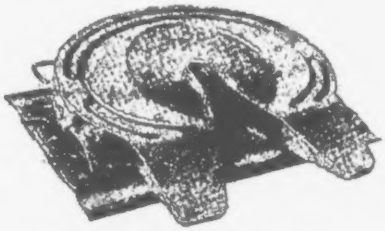
Figure 16



Courtesy of Holland Hitch Co.

b. Sliding mounting plate—Two types: Air type uses air cylinder to release lock on sliding mechanism; manual type uses lever to release lock on sliding mechanism

Figure 17



Courtesy of Holland Hitch Co.

Objective 15

Basic types of fifth wheel locking systems

a. Holland®

Figure 18—Type "A"

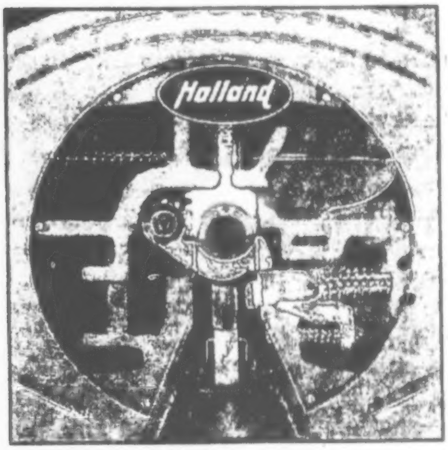
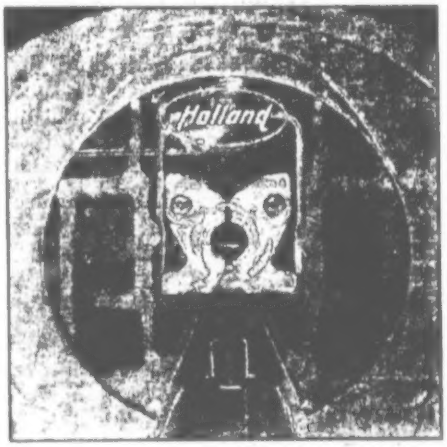


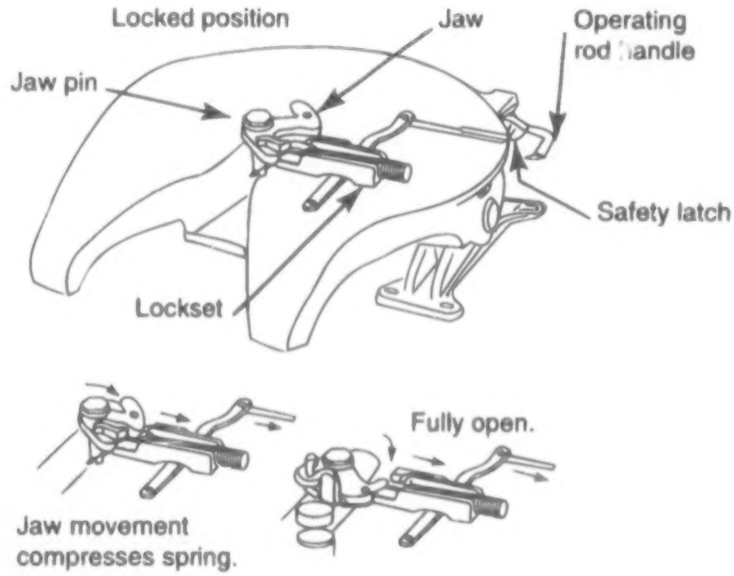
Figure 19—Type "B"



Courtesy of Holland Hitch Co.

b. Simplex®

Figure 20


Locked position
Jaw
Operating rod handle
Jaw pin
Safety latch
Lockset
Fully open.
Jaw movement compresses spring.

Courtesy of Freightliner Corporation

Objective 16

Main components of a typical fifth wheel (See Figure 21)

a. Skid ramp stop

b. Pick-up ramp

c. Skid ramp

d. Locking mechanism—Throat and coupler jaws

e. Skid plate

f. Base plate pivot

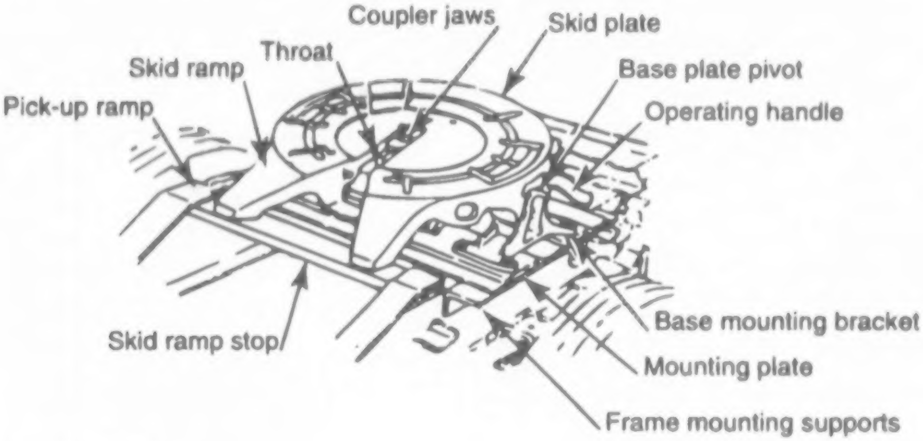
g. Operating handle

h. Base mounting bracket

i. Mounting plate

j. Frame mounting supports

Figure 21


Coupler jaws
Skid plate
Throat
Skid ramp
Base plate pivot
Pick-up ramp
Operating handle
Skid ramp stop
Base mounting bracket
Mounting plate
Frame mounting supports

Courtesy of Mack

Objective 17

Parts of a trailer

a. **Frame**

- Inside or outside rails—Provide support for the load
- Kingpin—Locks into the tractor's fifth wheel to connect the trailer to the tractor
- Bulkhead—Wall on the front of a trailer that prevents cargo from sliding into tractor during stops

- Floor, walls (inside and outside), ceiling, and roof—Parts of the van's box shell that protect the cargo; commonly made of aluminum and reinforced, lightweight material such as fiberglass reinforced plastic (FRP)
- Doors—Allow access to the cargo; commonly swinging type or roll-up type

b. **Running gear**

- Axles—Carry the weight of the cargo and transmit the load to the wheels
- Wheels—Transmit the weight of the cargo from the axles to the tires; provide rotary motion
- Tires—Transmit the weight of the cargo from the wheels to the road; provide traction
- Brakes—Slow and stop movement; consist of service brakes and emergency brakes
- Suspension system—Used to provide a smooth ride for driver and cargo
- Sliding tandems—Used to adjust the wheelbase of the trailer to help distribute trailer weight
- Landing gear—Holds up the front of the trailer when the trailer isn't hooked to the tractor

c. **Lights and electrical wiring**—Include clearance lights, turn signals, parking lights, rear lights, and brake lights. Wires that control these lights are contained in the "pigtail" at the front of the trailer.

d. **Air system**—Consists of two air couplings ("glad hands") that transmit air pressure from the tractor to the trailer brakes

- One glad hand provides air to the service brakes (pressurized only when brakes are applied).
- Other glad hand provides air to emergency brakes (pressurized at all times).

Student Supplement 1—Body-Bound Bolt Charts

METRIC BODY-BOUND BOLT CHART

B/B Bolt mm	Shank Dia. mm (in.)	Reamer No.	Recommended Drill Size mm (in.)	Torque N•m, (lb. ft.)
12	12.70 (0.500) 12.60 (0.496)	J34922 (12.6 mm)	11 (0.433)	65 (48)
16	16.69 (0.657) 16.59 (0.653)	J26461 (0.652 in.)	15 (0.590)	150 (111)
20	20.70 (0.815) 20.60 (0.811)	J34679 (20.5 mm)	19 (0.748)	210 (155)

GRADE 5 BODY-BOUND BOLT CHART

Bolt Size	Shank Dia. in. (mm)	Reamer No.	Recommended Drill Size in. (mm)	Torque Limits lb. ft., (N•m)
5/8-18 UNF-2A	0.657/0.653 (16.69/16.59)	J-26461	0.593 (15.06)	160 to 170 (217 to 230)
3/4-16 UNF-2A	0.782/0.778 (19.86/19.76)	J-26462	0.688 (17.47)	240 to 270 (325 to 366)
1-14 UNS-2A	1.034/1.028 (26.26/26.11)	J-26463	0.968 (24.59)	590 to 640 (800 to 868)

GRADE 8 BODY-BOUND BOLT CHART

Bolt Size	Shank Dia. in. (mm)	Reamer No.	Recommended Drill Size in. (mm)	Torque Limits lb. ft., (N•m)
5/8-18 UNF-2A	0.657/0.653 (16.69/16.59)	J-26461	0.593 (15.06)	170 to 190 (230 to 258)
3/4-16 UNF-2A	0.782/0.778 (19.96/19.76)	J-26462	0.688 (17.47)	240 to 260 (325 to 352)

Courtesy of Mack

Objective 18

Job Sheet 1—Inspect and Install or Repair Frame, Hangers, Brackets, and Cross Members

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Correct procedures identified for assigned vehicle	______
• Procedures completed correctly	______
• Proper tools used correctly	______
• Safety precautions observed	______
• Installed equipment functions correctly	______
• Serviced equipment meets specifications	______
• Clean-up and follow-up actions adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Truck to be inspected
- Soapstone
- Reamer set
- Drill motor and drill bit set
- Hand tools
- Torque wrench

Guidelines

- Most manufacturers recommend that cracked or damaged frame rails be replaced. Check manufacturer's procedures before welding or repairing any frame rails.

- When tightening the fasteners, tighten the nut, not the bolt head. This will give a true torque reading by eliminating bolt body friction.

- Apply an anti-corrosion compound to all bolts, nuts, and washers that contact aluminum parts.

- Many times you may need to remove a crossmember, hanger, bracket, or drill a hole to remove or repair other components on a vehicle.

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Set parking brake, remove ignition key, and chock wheels.

☐ 4. Check and inspect frame for loose bolts and cracks.

☐ 5. Refer to body-bound bolt charts (Student Supplement 1) for correct drill size and reamer size.

☐ 6. Never drill holes closer than 1 inch from the outer face of the flange.

☐ 7. Mark location with soapstone and center punch.

☐ 8. Fill all unused holes in the frame assembly with the applicable nut, washer, and bolt combination.

☐ 9. Remove all components from cross member such as air valves, air tanks, lights, and lines before removing.

☐ 10. Remove the fasteners that attach the cross member to the frame. Note the direction that the bolts are installed. If equipped with spacers, remove them.

☐ 11. If removing a midship bearing cross member, support the driveline on a safety stand.

☐ 12. Slide the cross member out the rear of the frame rails, lifting it or lowering it as needed to clear frame.

☐ 13. Replace cross member in reverse procedure. Install all bolts before tightening bolts to correct torque.

☐ 14. Use the same guidelines when replacing hangers and brackets.

☐ 15. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

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PARTS LIST

QTY.	PARTS/MATERIALS	PRICE
TOTAL PARTS/MATERIALS		

SPECIFICATIONS CHECKED

School/Work Name ____________________

Address ____________________

Phone # ____________________

Date In ____________

Date Out ____________

JOB TICKET

Customer Name ____________________

Customer Address ____________________

Customer Phone # ____________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________________

Services/repairs made:	LABOR

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________________ Date ____________

Technician ____________

Supervisor ____________

Objective 19

Job Sheet 2—Check and Inspect Vehicle Frame Alignment

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Correct procedures identified for assigned vehicle	______
• Procedures completed correctly	______
• Proper tools used correctly	______
• Safety precautions observed	______
• Installed equipment functions correctly	______
• Serviced equipment meets specifications	______
• Clean-up and follow-up actions adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Truck frame with fifth wheel removed
- Pencil or soapstone
- Tape measure
- Machinist's square
- Large hammer and wooden block
- Hand tools

Guidelines

- Use a pencil or soapstone to make all lines, points, or other marks.
- Do not use any marker or tool that will scratch the surface of the frame rail.
- Use a machinist's square to project all points from the webs to the upper flanges, and to measure inboard from the outside face of the frame rails.

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Set parking brake, remove ignition key, and chock wheels.

☐ 4. Inspect frame for loose bolts, cracks, and uneven surfaces before checking frame alignment.

☐ 5. For each frame rail, project the exact vertical centerline of the frame station 100 mark, from the frame web to the top flange, and mark it with a line across the top flange.

☐ 6. Find the exact center of the width of each upper flange, and mark the point on each projected line. This will be the forward set of points. The forward points must be in identical locations on both frame rails.

☐ 7. Measure back along each frame rail to find a set of bolt holes at least 72 inches rearward from the forward set of points. The holes must be in the same location in each frame rail.

☐ 8. Project the exact vertical centerline of each bolt hole, and mark a line across the top flange of its respective frame rail.

☐ 9. Along each line, measure and mark a point 2 inches inboard from the outside face of its respective frame rail. The rear points must be in identical locations on both frame rails.

☐ 10. Measure the distance from the forward point on one frame rail to the rear point on the opposite frame rail. Then measure the distance from the other forward point to the rear point on its opposite frame rail. Compare the two measurements.

☐ 11. If measurement is not within specifications, loosen all of the frame fasteners just enough to allow movement of the parts when force is applied. Using a large hammer and a large wooden block, place the block against the rear end of the frame rail that had its rear point the greater distance from its opposite rail's front point. Tap the block until the measurements are within specification.

☐ 12. Tighten all of the frame fasteners, starting at the middle of the frame and working alternately toward both ends.

☐ 13. If the frame rails needed aligning, check the axle alignment. Refer to service manual or instructor.

☐ 14. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

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PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________________

Address ____________________

Phone # ____________________

Date In ____________

Date Out ____________

JOB TICKET

Customer Name ____________________

Customer Address ____________________

Customer Phone # ____________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________________

____

Services/repairs made: ____________________

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________________ Date ____________

Technician ____________

Supervisor ____________

Objective 20

Job Sheet 3—Inspect and Service Fifth Wheel Assemblies, Pintle Hitch, Kingpin, and Trailer Plate

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation Criteria	Rating
• Correct procedures identified for assigned vehicle	______
• Procedures completed correctly	______
• Proper tools used correctly	______
• Safety precautions observed	______
• Installed equipment functions correctly	______
• Serviced equipment meets specifications	______
• Clean-up and follow-up actions adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Truck tractor with fifth wheel and trailer
- Grease gun
- Torque wrench
- Jaw/Kingpin gauge
- Hand tools

Guidelines

- Fifth wheels must be regularly inspected and properly serviced. This will include general inspection, jaw/kingpin clearance check and adjustment, and lubrication.

- When replacing any fasteners, make sure you refer to the manufacturer's parts book for fastener specifications.

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Set parking brake, remove ignition key, and chock wheels on truck tractor with trailer uncouple.

☐ 4. Identify make and model of fifth wheel.

☐ 5. Clean fifth wheel assembly and frame if needed.

☐ 6. Inspect fifth wheel assembly and slider assembly for any cracked, broken, bent, or missing parts and report needed repairs on shop ticket.

☐ 7. Torque all mounting bolts to manufacturer's recommended level.

☐ 8. Inspect for sharp edges at top of plate and chamfer 1/8" to 1/4" as required.

☐ 9. Check jaw/kingpin clearance with gauge.

☐ 10. Adjust jaw/kingpin clearance if excessive. Use correct procedure described in service manual.

Note: Every manufacturer has different adjustment procedures.

☐ 11. Check jaw/kingpin clearance after adjustment.

☐ 12. Lubricate all grease fittings.

☐ 13. Maintain a heavy grease coating on the top surface of the wheel either through the grease fittings located on the underside of the plate or by direct application.

☐ 14. Apply grease directly to lock mechanism.

☐ 15. Inspect and check kingpin and plate on trailer for wear.

☐ 16. Inspect and check pintle hitch at rear of trailer for loose or worn parts and report needed repairs on shop ticket.

☐ 17. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____________________

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____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________________
Address ____________________
Phone # ____________________

Date In __________
Date Out __________

JOB TICKET

Customer Name ____________________
Customer Address ____________________
Customer Phone # ____________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________________

Services/repairs made:	**LABOR**	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________________ Date __________

Technician __________
Supervisor __________

Objective 21

Job Sheet 4—Couple and Uncouple Fifth Wheel

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Correct procedures identified for assigned vehicle	______
• Procedures completed correctly	______
• Proper tools used correctly	______
• Safety precautions observed	______
• Installed equipment functions correctly	______
• Serviced equipment meets specifications	______
• Clean-up and follow-up actions adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Truck trailer with fifth wheel
- Trailer (van or flatbed)

Guidelines

> Caution: The improper installation, use, and/or maintenance of any fifth wheel can result in an unintended separation of the trailer from the tractor with potential for serious personal injury or loss of life and/or major property damage.

- Fifth wheels must be regularly inspected and properly serviced. This will include general inspection, jaw/kingpin clearance check and adjustment, and lubrication.

- Some wheels can require additional steps. Follow the manufacturer's guidelines

Procedure

Coupling

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Make sure you have had instruction on the operation of a truck-tractor and understand all controls before attempting the procedure.

☐ 4. Inspect the area around the tractor before moving.

☐ 5. Horizontally align the tractor in front of the trailer.

☐ 6. Make sure mirrors are adjusted so the corners of trailer will appear evenly in the mirrors.

☐ 7. Stop when the rear of the tractor is about five feet from the front of the trailer. SET PARKING BRAKE.

☐ 8. Inspect the area around the trailer and tractor, and make sure that the trailer wheels are chocked.

☐ 9. Inspect fifth wheel and stationary brackets on slider for damaged or missing parts and loose or missing mounting bolts.

☐ 10. Be sure that top surface of fifth wheel is tilted downward to the rear and adequately lubricated. Adjust landing gear so that first contact of the trailer to the fifth wheel plate will be approximately 8" behind bracket center.

☐ 11. Be sure that fifth wheel jaw is open and operating rod is at extended position.

☐ 12. Check alignment of the fifth wheel with kingpin. Slowly back the tractor up to the trailer so the coupling assemblies connect without moving the trailer backwards.

☐ 13. Visually inspect to make sure that there is no gap between the fifth wheel and trailer bed plate, that operating rod is fully retracted, and that kingpin is in fifth wheel slot with jaw closed behind pin.

☐ 14. Connect air and electrical connections, raise the landing gear, and release the parking brakes. Pull forward slowly checking for slack or looseness in the fifth wheel locking jaws or mounting.

Note: Air lines may be color coded red and blue.

Procedure

Uncoupling

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Park tractor and trailer on a level surface that will support trailer. Apply tractor and trailer parking brakes.

☐ 4. Place chock blocks at trailer wheels and lower trailer landing gear sufficiently to raise trailer approximately 1/2".

☐ 5. Disconnect air and electrical connections.

☐ 6. Check trailer load. If loaded, make sure load is even and not only at front of trailer. This could cause trailer to tilt and damage trailer and load.

☐ 7. Unlock the fifth wheel, raise the safety latch, and pull the operating handle out or forward to release jaws from kingpin.

☐ 8. Release the tractor brakes and pull the tractor away from trailer slowly making sure that trailer is supported.

Evaluator's Comments: ______________________________

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________________

Address ____________________

Phone # ____________________

Date In ____________

Date Out ____________

JOB TICKET

Customer Name ____________________

Customer Address ____________________

Customer Phone # ____________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________________

Services/repairs made:	LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________________ Date ____________

Technician ____________

Supervisor ____________

Steering Column and Manual Steering Gear

Unit Contents

Student Components

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Information Sheet 1B–5

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1—Diagnose and Troubleshoot Problems on the Steering Column and Steering Gear Assembly 1B–15
2—Remove Steering Wheel, Inspect, Repair, or Replace to Proper Alignment Position 1B–19
3—Remove, Disassemble,and Remount the Steering Gear Assembly 1B–23
4—Perform Steering Gear Adjustments 1B–27
5—Inspect and Replace Pitman Arm on Steering Gear Assembly . 1B–31
6—Inspect and Replace Steering U-Joints 1B–35

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Unit 1-B

Steering Column and Manual Steering Gear

Objective Sheet

Unit Objective

After completing this unit, the student should be able to discuss operation, repair, and replacement of the steering column and steering gear assemblies. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to steering column and manual steering gear with their definitions.
2. State purposes of a steering column and steering gear assembly.
3. Describe the basic types of steering columns.
4. Match the parts of a standard steering column and manual steering gear assembly with the correct illustrations.
5. Identify the parts of a tilt/telescoping steering column assembly.
6. Label the parts of a universal joint.
7. Identify the basic types of manual steering gears.
8. Distinguish among the operation of manual steering gears.
9. List common problems or complaints on manual steering gears.
10. Match common adjustments made on manual steering gears with their correct main purposes.
11. Identify specialty tools used for work on steering systems.
12. Name common lubricants used in steering gear assemblies.
13. Diagnose and troubleshoot problems on the steering column and steering gear assembly. (Job Sheet 1)
14. Remove steering wheel, inspect, repair, or replace to proper alignment position. (Job Sheet 2)
15. Remove, disassemble, and remount the steering gear assembly. (Job Sheet 3)
16. Perform steering gear adjustments. (Job Sheet 4)
17. Inspect and replace pitman arm on steering gear assembly. (Job Sheet 5)
18. Inspect and replace steering u-joints. (Job Sheet 6)

Information Sheet

Objective 1

Terms and definitions

a. **Bearing preload**—Amount of pressure put on a bearing to reduce slack in the bearing

b. **Manual steering gear**—Mechanical device used to convert the rotary motion at the steering wheel to a lateral motion at the steering axle

c. **Pitman arm**—Part connecting the steering gear shaft and steering linkage

d. **Shims**—Thin pieces of metal in various thicknesses that may be used to preload bearings

e. **Slack**—Excessive movement between components

Note: This may also be called backlash, freeplay, excess travel, or looseness.

f. **Steering column**—Component fastened to cab instrument panel that houses the steering shaft with bearing supports and that provides connection between steering wheel and steering gear assembly

g. **Steering ratio**—Numerical ratio representing the number of turns made by the steering wheel to steering lever shaft

h. **Steering shaft**—Tube or rod that connects the steering wheel (cab mounted) to the steering gear (chassis mounted)

i. **Steering u-joint**—Universal joint used to connect the steering column to the steering shaft and steering gear assembly

j. **Steering wheel**—Wheel assembly mounted on top of the steering column that transfers driver input turning torque effort to the steering gear which in turn controls direction of the vehicle

k. **Stud**—Hinge-like fastener (ball- or tapered cone-shape) where adjustments can be made to reduce slack

l. **Telescoping**—Adjusting height by means of sliding inner and outer tubes

m. **Tilting**—Adjusting angle by rotation forward (up) or rearward (down)

Information Sheet

Objective 2

Purposes of steering column and steering gear assembly

a. To allow the operator to position the wheels which control the direction of travel

b. To allow the turning of the front wheels with a reasonable effort

c. To transmit the feel of the road to the operator

Objective 3

Basic types of steering columns

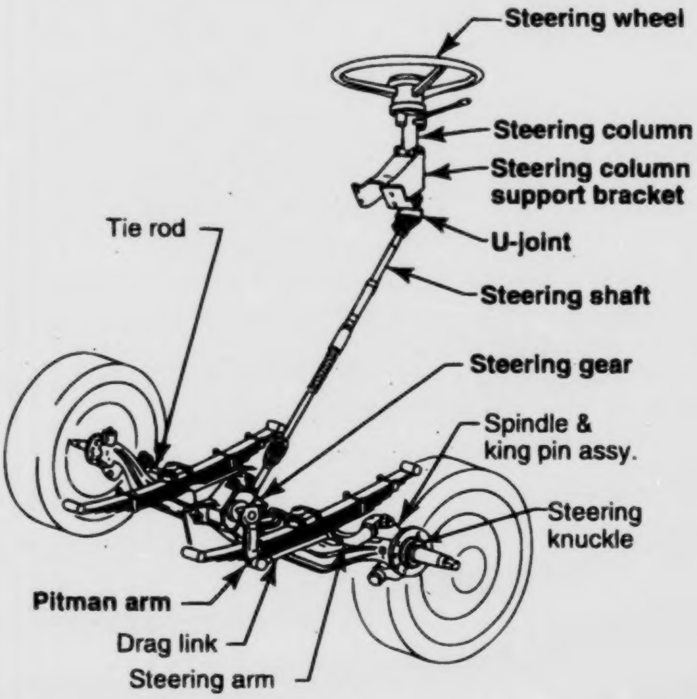
a. **Fixed** (standard)—Steering wheel cannot be moved; steering wheel is permanently placed in a position that suits the average driver's size and range of seat positions

b. **Adjustable** (tilt-telescoping)—Steering wheel can be moved in height and/or angle to provide optimum wheel-to-driver relationship in all seat positions

Objective 4

Parts of standard steering column and manual steering gear assembly

Figure 1


Steering wheel
Steering column
Steering column support bracket
Tie rod
U-joint
Steering shaft
Steering gear
Spindle & king pin assy.
Steering knuckle
Pitman arm
Drag link
Steering arm

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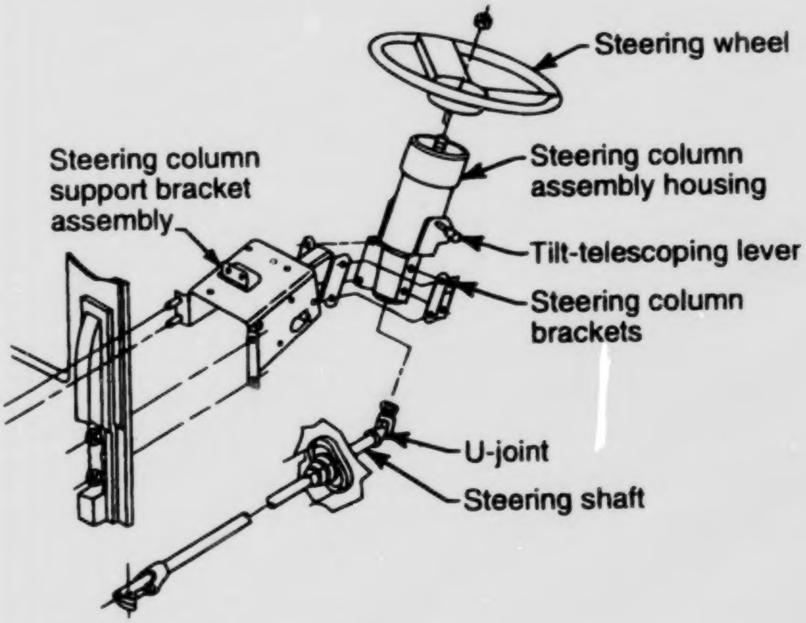
Objective 5

Parts of a tilt/telescoping steering column assembly

Figure 2


Steering wheel
Steering column support bracket assembly
Steering column assembly housing
Tilt-telescoping lever
Steering column brackets
U-joint
Steering shaft

Courtesy of Navistar International Transportation Corp.

Objective 6

Parts of a universal joint (u-joint)

Figure 3

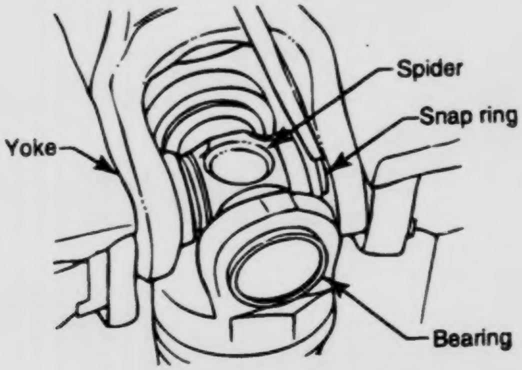
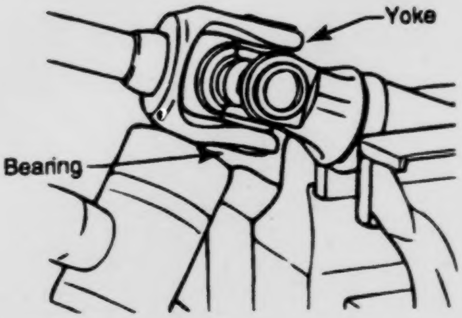

Spider
Snap ring
Yoke
Bearing

Figure 4


Yoke
Bearing

Courtesy of Navistar International Transportation Corp.

Objective 7

Basic types of manual steering gears

a. **Recirculating ball manual steering gear**

Figure 5–Side view

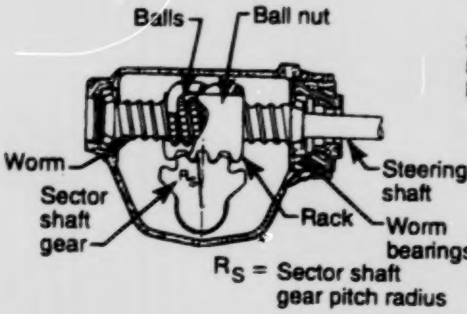
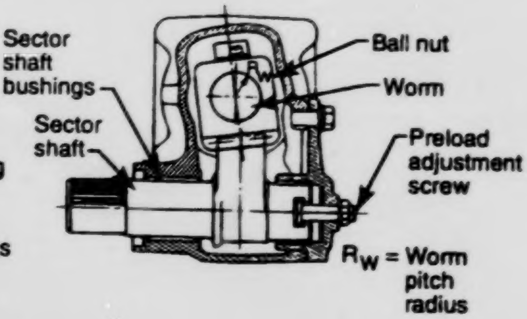

Balls
Ball nut
Worm
Sector shaft gear
R_S
Rack
Steering shaft
Worm bearings
R_S = Sector shaft gear pitch radius

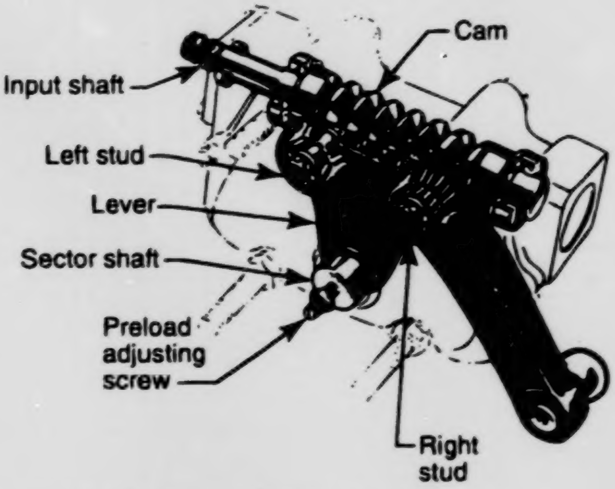
Figure 6—End view


Sector shaft bushings
Sector shaft
R_W
Ball nut
Worm
Preload adjustment screw
R_W = Worm pitch radius

Courtesy of TRW Commercial Steering Division

b. **Cam and lever manual steering gear**

Figure 7—Pictorial view


Cam
Input shaft
Left stud
Lever
Sector shaft
Preload adjusting screw
Right stud

Courtesy of TRW Commercial Steering Division

Cam and lever manual steering gear (continued)

Figure 8–Side view

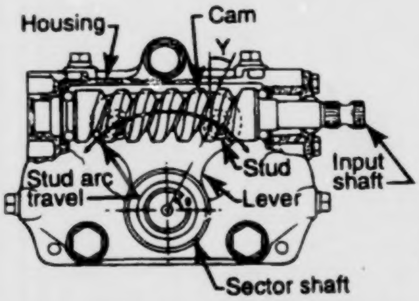
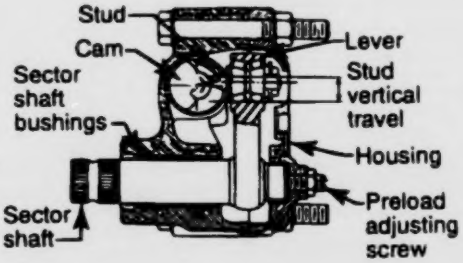

Housing
Cam
Stud
Input shaft
Stud arc travel
Lever
Sector shaft

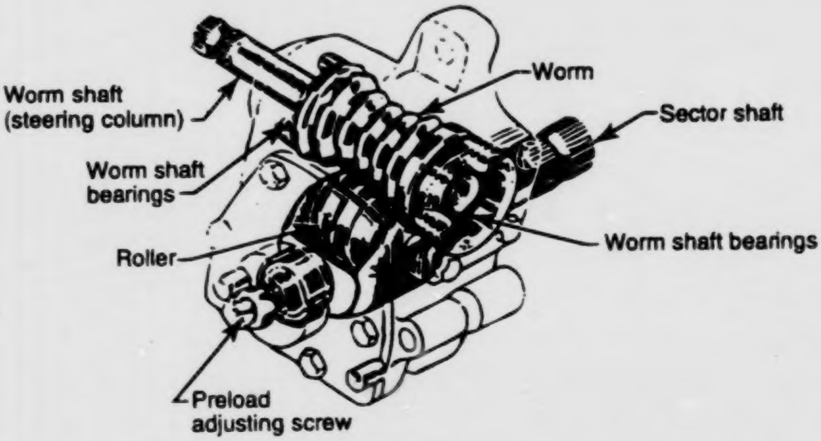
Figure 9—End view


Stud
Cam
Sector shaft bushings
Lever
Stud vertical travel
Housing
Preload adjusting screw
Sector shaft

Courtesy of TRW Commercial Steering Division

c. **Worm and roller manual steering gear**

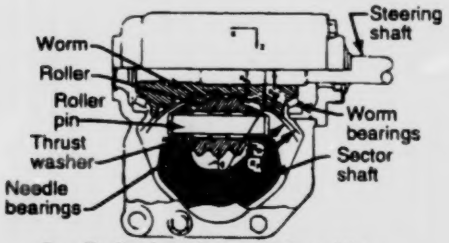
Figure 10—Pictorial view


Worm
Worm shaft (steering column)
Sector shaft
Worm shaft bearings
Worm shaft bearings
Roller
Preload adjusting screw

Courtesy of TRW Commercial Steering Division

Worm and roller manual steering gear (continued)

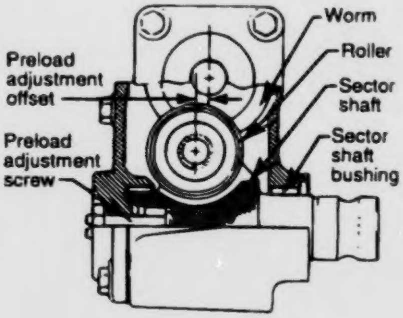
Figure 11—Side view


Steering shaft
Worm
Roller
Roller pin
Thrust washer
Needle bearings
Worm bearings
Sector shaft

R_R = Radius from the center line of the sector shaft to the contact point of the worm

R_P = Radius of the worm pitch line

Figure 12—End view


Worm
Roller
Sector shaft
Sector shaft bushing
Preload adjustment offset
Preload adjustment screw

Courtesy of TRW Commercial Steering Division

Objective 8

Operation of manual steering gears

a. **Recirculating ball**

- The input shaft portion has a semicircular grooved helix which provides one half of the path of travel for the recirculating balls.
- The other half of the path for the balls is a mating semicircular grooved helix cut on the inside of the nut.
- As the input shaft rotates, the helix causes the balls to circulate and to force the nut up or down the input shaft.
- The lower surface of the nut is cut with gear teeth on a rack which mesh with the gear teeth on the sector shaft. This converts the linear motion of the nut into rotational motion of the sector shaft.

b. **Cam and lever**

- Uses a constant diameter worm (called a cam in this case) on the input shaft and a cone shaped stud on the lever
- As the cam turns, the stud follows and converts the arched motion of the contact point into sector shaft rotation.

c. **Worm and roller**

- Features an hourglass worm gear on the input shaft with a rotating toothed follower on the sector shaft
- As the input worm turns, the roller follows and converts the curvilinear motion on the worm axis into sector shaft rotation.

Objective 9

Common problems or complaints on manual steering gears

a. Excess slack (looseness)

- Caused by worn steering gear
- Caused by worn u-joints

b. Hard turning or steering

c. Binding

d. Locking

e. Pulling to one side

f. Noisy steering

Objective 10

Common adjustments made on manual steering gears and their main purposes

a. **Side cover adjustment** (mid-travel)—To reduce travel (slack) on steering gear

b. **Travel-stop adjustment**—To limit travel of wheels to prevent wheels from rubbing frame

c. **Preload bearings on worm gear in steering gear**—To reduce end travel; made with shims or adjusting plugs or screws

Note: This is usually the first step in steering gear overhaul. Some types of steering gears require clearance on the worm gear bearing instead of preload. Check the manufacturer's recommendations.

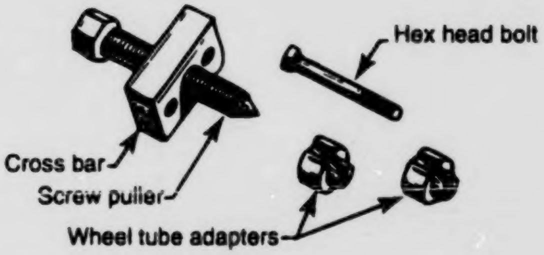
d. **Ball stud adjustment**—To reduce slack (looseness) on pitman arm or steering arm

Objective 11

Specialty tools used to work on steering systems

a. **Steering wheel puller**—Used to remove steering wheel from steering column

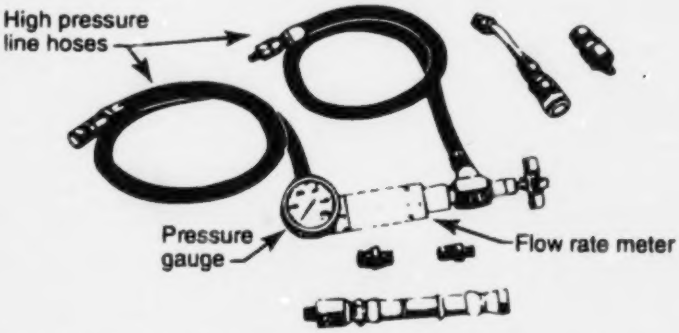
Figure 13



Courtesy of Kent-Moore/SPX Corporation

b. **Power steering analyzer (tester)**—Used to check hydraulic operation (flow rate and pressure) through the power steering system

Figure 14


High pressure line hoses
Pressure gauge
Flow rate meter

Courtesy of Kent-Moore/SPX Corporation

c. **Pitman arm puller**—Used to remove pitman arm from steering gear; two basic types

Figure 15—Bar type

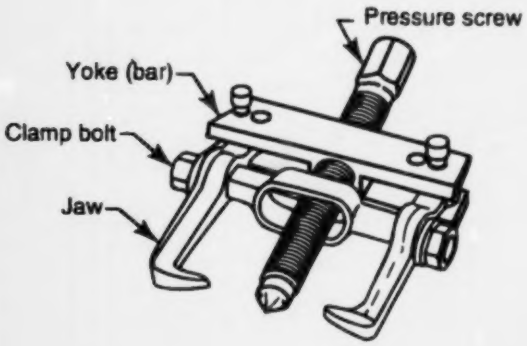
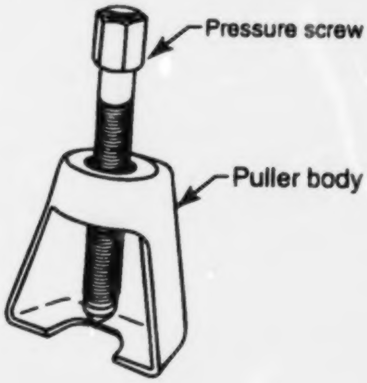
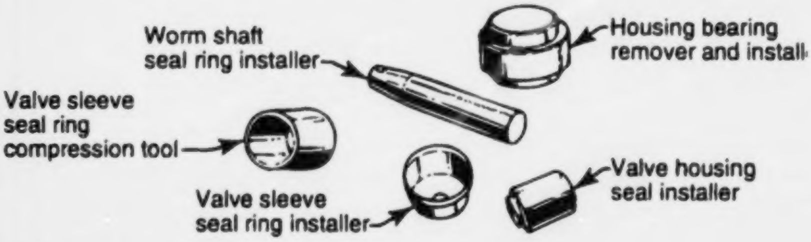

Pressure screw
Yoke (bar)
Clamp bolt
Jaw

Figure 16—Specialty type


Pressure screw
Puller body

d. **Special compression, installation, and removal tools**—Used to work on various seals and bearings used in the steering system

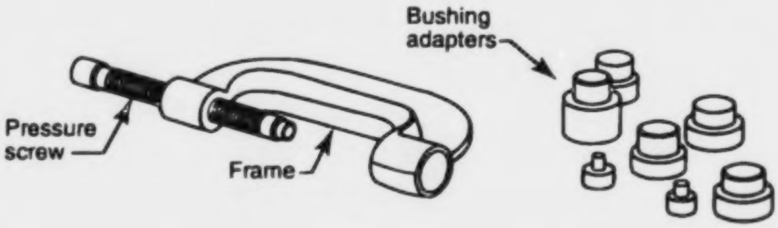
Figure 17


Worm shaft seal ring installer
Housing bearing remover and install
Valve sleeve seal ring compression tool
Valve sleeve seal ring installer
Valve housing seal installer

Courtesy of Kent Moore/SPX Corporation

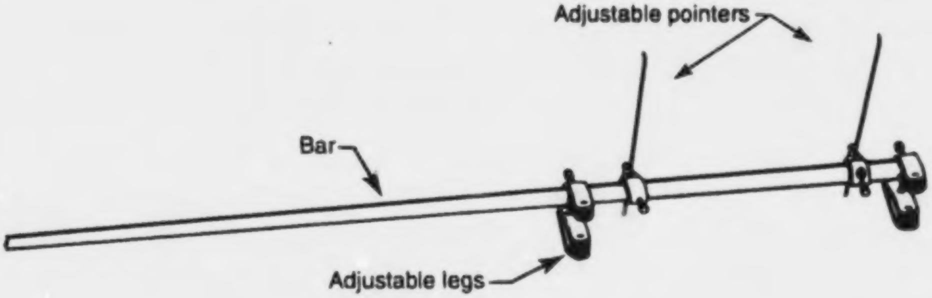
e. **Universal joint tool**—Used for work on the u-joint

Figure 18


Bushing adapters
Pressure screw
Frame

f. **Trammel bar gauge** (alignment bar)—Used to check front end alignment

Figure 19


Adjustable pointers
Bar
Adjustable legs

Objective 12

Common lubricants used in steering gear assemblies

a. SAE 80W-90 gear lubricant API GL-5

b. SAE 50W HD mineral oil

Note: Refer to equipment service or maintenance manual for recommended lubricant.

Objective 13

Job Sheet 1—Diagnose and Troubleshoot Problems on the Steering Column and Steering Gear Assembly

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Driver/operator is asked to state the problem	______
• Technician operates system to check out problem	______
• Findings and needed repairs/parts are listed on repair job ticket	______
• Cleanup is adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Steering column and steering gear assembly to be checked.
- Others—as recommended by instructor and equipment service manual

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual or troubleshooting guide. The nine basic steps to troubleshoot the system include the following:

  ☐ a. Ask the driver/operator to state the problem clearly and concisely.

  ☐ b. Operate the equipment with the driver/operator to identify the problem.

  ☐ c. Inspect the vehicle/equipment to gather and organize facts.

  ☐ d. Use troubleshooting guide to list the probable causes.

  ☐ e. Reach a conclusion and start with most probable cause.

☐ f. Communicate with owner/operator about your conclusion.

☐ g. Make repairs as directed and approved.

☐ h. Test and operate equipment.

☐ i. Follow-up with driver/operator to make sure problem has been corrected.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________________
Address ____________________
Phone # ____________________

Date In ____________
Date Out ____________

JOB TICKET

Customer Name ____________________
Customer Address ____________________
Customer Phone # ____________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________________

Services/repairs made: ____________________

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________________ Date ____________

Technician ____________
Supervisor ____________

Objective 14

Job Sheet 2—Remove Steering Wheel, Inspect, Repair, or Replace to Proper Alignment Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Proper tools are used	______
• Service manual is used properly	______
• Steps are followed	______
• Job ticket is filled out properly	______
• Findings are performed	______
• Proper alignment position is obtained	______
• Cleanup is adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Torque wrench
- Steering wheel puller
- Steering wheels to be worked on
- Others—as recommended by instructor and equipment service manual

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Disconnect battery cable so horn will be disconnected.

☐ 4. Remove horn cover to expose steering wheel nut.

☐ 5. Remove steering wheel nut.

☐ 6. Mark location of steering wheel in column so it can be replaced correctly.

☐ 7. Remove steering wheel using the appropriate steering wheel puller.

☐ 8. Inspect and clean parts as needed.

☐ 9. Have instructor check your work so far. Discuss repairs/replacements needed.

Bench check ______________

☐ 10. Obtain instructor's and customer's approval for repairs/replacements to be made. Have them sign job ticket.

☐ 11. Repair or replace parts as approved. Record on job ticket.

☐ 12. Reassemble making sure steering wheel is properly aligned.

☐ 13. Torque fasteners as required.

☐ 14. Have instructor check your work.

Final check ______________

☐ 15. Turn in job ticket when finished.

☐ 16. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________________

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ______________________

Address ______________________

Phone # ______________________

Date In ____________

Date Out ____________

JOB TICKET

Customer Name ______________________

Customer Address ______________________

Customer Phone # ______________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ______________________

Services/repairs made: ______________________

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

______________________ Date ____________

Technician ____________

Supervisor ____________

Objective 15

Job Sheet 3—Remove, Disassemble, and Remount the Steering Gear Assembly

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Service manual is used properly	______
• Parts are inspected accurately	______
• Job ticket findings are recorded	______
• Specifications are checked	______
• Cleanup is adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Torque wrench
- Pitman arm puller
- Steering gear assembly to be worked on
- Others—as recommended by instructor and equipment service manual

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Disconnect steering column linkage and steering arm linkage.

☐ 4. Remove steering gear assembly.

☐ 5. Disassemble steering gear assembly.

☐ 6. Inspect and clean parts as needed.

☐ 7. Have instructor check your work so far. Discuss repairs/replacements needed.

Bench check ______________

☐ 8. Obtain instructor's and customer's approval for repairs/replacements to be made. Have them sign job ticket.

☐ 9. Repair or replace parts as approved and adjust as required. Record on job ticket.

☐ 10. Check lubricant level. Replace as needed.

☐ 11. Mount steering gear on frame assembly and hook-up column and steering linkages.

☐ 12. Recheck operation and adjust if needed.

☐ 13. Torque fasteners as required.

☐ 14. Have instructor check your work.

Final check ______________

☐ 15. Turn in job ticket when finished.

☐ 16. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name __________

Address __________

Phone # __________

Date In __________

Date Out __________

JOB TICKET

Customer Name __________

Customer Address __________

Customer Phone # __________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: __________

Services/repairs made: __________

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

__________ Date __________

Technician __________

Supervisor __________

Objective 16

Job Sheet 4—Perform Steering Gear Adjustments

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	____
• Safety procedures are followed	____
• Proper tools are used	____
• Service manual is used properly and steps on adjustments are followed	____
• Job ticket is filled out properly	____
• Adjustments are made	____
• Cleanup is adequate	____

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Torque wrench
- Steering gear to be worked on
- Others—as recommended by instructor and equipment service manual

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Discuss with instructor which adjustments are needed. Typical adjustments include:

a. Side cover (mid-travel) adjustment

b. Travel-stop adjustment

c. Others as specified in service manual

☐ 4. Obtain instructor's and customer's approval for adjustments to be made. Have them sign job ticket.

☐ 5. Make adjustments as approved. Record on job ticket.

☐ 6. Have instructor check your work.

Final check ______________

☐ 7. Turn in shop ticket when finished.

☐ 8. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________
Address ____________
Phone # ____________

Date In ____________
Date Out ____________

JOB TICKET

Customer Name ____________
Customer Address ____________
Customer Phone # ____________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________

Services/repairs made:	**LABOR**	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________ Date ____________

Technician ____________
Supervisor ____________

Objective 17

Job Sheet 5—Inspect and Replace Pitman Arm on Steering Gear Assembly

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Parts are inspected	______
• Job ticket filled out on repair performed	______
• Service manual and specifications used	______
• Cleanup is adequate	______

Basic Skills

Reading   Writing   Critical Thinking   Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Torque wrench
- Pitman arm puller
- Steering gear assembly to be worked on
- Others—as recommended by instructor and equipment service manual

Procedure

Note: This task was included as one of the subtasks in Job Sheet 3. The only time you would need to do this job sheet alone is when the ball stud or splines are worn and the pitman arm needs replacement.

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Remove locknut and washer holding pitman arm on steering gear.

> Caution: Check for alignment markings on pitman arm to steering gear shaft. Mark as needed.

☐ 4. Remove steering arm linkage.

☐ 5. Install pitman arm puller and remove pitman arm.

☐ 6. Inspect and clean parts as needed.

☐ 7. Have instructor check your work so far. Discuss replacement to be made.

Bench check ______________

☐ 8. Obtain instructor's and customer's approval for replacement to be made. Have them sign job ticket.

☐ 9. Repair or replace pitman arm as approved. Record on job ticket.

☐ 10. Remount linkage.

☐ 11. Torque fasteners as required, and adjust ball stud if used.

☐ 12. Have instructor check your work.

Final check ______________

☐ 13. Turn in shop ticket when finished.

☐ 14. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________________
Address ____________________
Phone # ____________________

Date In __________
Date Out __________

JOB TICKET

Customer Name ____________________
Customer Address ____________________
Customer Phone # ____________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________________

Services/repairs made: ____________________

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________________ Date __________

Technician __________
Supervisor __________

Objective 18

Job Sheet 6—Inspect and Replace Steering U-Joints

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Job ticket filled out on steering u-joint replacement	______
• Service manual procedures are followed	______
• Proper tools are used	______
• Cleanup is adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Steering gear assembly to be worked on
- Others—as recommended by instructor and equipment service manual

Procedure

Caution: Use care to prevent collapsing the yoke.

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Remove snap rings.

☐ 4. Remove bearing caps.

☐ 5. Inspect parts as needed.

☐ 6. Have instructor check your work so far. Discuss replacement to be made.

Bench check ______________

☐ 7. Obtain instructor's and customer's approval for repairs/replacements to be made. Have them sign job ticket.

☐ 8. Repair or replace parts as approved. Record on job ticket.

☐ 9. Press bearing into yoke.

☐ 10. Install snap rings.

☐ 11. Check for freedom of movement and proper alignment.

☐ 12. Have instructor check your work.

Final check ______________

☐ 13. Turn in shop ticket when finished.

☐ 14. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________________

Address ____________________

Phone # ____________________

Date In ____________

Date Out ____________

JOB TICKET

Customer Name ____________________

Customer Address ____________________

Customer Phone # ____________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________________

Services/repairs made: ____________________

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________________ Date ____________

Technician ____________

Supervisor ____________

Unit Contents

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2—Remove and Repair/Replace Power Steering Gear 2B-23
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4—Remove and Replace Power Steering Pump; Adjust Belt if Used 2B-31
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Objective Sheet

Unit Objective

After completing this unit, the student should be able to discuss operation of power steering systems, diagnose system problems, and repair and replace power steering system components. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to power steering systems with their definitions.
2. Select from a list the purposes of power steering systems.
3. Match basic components of a power steering assembly with their correct functions.
4. Describe the basic differences between manual steering and power steering.
5. Distinguish between the common types of power steering systems.
6. Identify the parts of an integral power steering assembly.
7. Identify the parts of a semi-integral power steering assembly.
8. Identify power steering gear and valve operation flow for right turn, neutral position, and left turn steering maneuvers.
9. Name common types of lubricants used in power steering systems.
10. Distinguish between the types of lines used on power steering assemblies.
11. List the two basic types of power steering reservoirs.
12. Identify the types of hydraulic pumps used on power steering systems.
13. Identify the two means of mounting power steering pumps.
14. Complete a chart of common pump problems and possible causes.
15. Diagnose, test, and troubleshoot problems on a power steering system. (Job Sheet 1)
16. Remove and repair/replace power steering gear. (Job Sheet 2)
17. Rebuild power steering gear. (Job Sheet 3)

18. Remove and replace power steering pump; adjust belt if used. (Job Sheet 4)

19. Inspect, clean, disassemble, and rebuild power steering pump; replace worn parts. (Job Sheet 5)

20. Test and repair/replace flow control/pressure relief valve(s) on power steering pump. (Job Sheet 6)

21. Fill and bleed the power steering system. (Job Sheet 7)

Information Sheet

Objective 1

Terms and definitions

a. **Integral**—Formed as a unit with another part

Examples: Pump with integral reservoir, pump with integral control valve

b. **Power steering gear**—Steering mechanism powered by hydraulic pressure

c. **Power steering assembly**—Collection of parts combined for the purpose of power steering

d. **Power steering hydraulic tester**—Device used to test, troubleshoot, and adjust hydraulics in power steering system

e. **Remote**—One part operating at some distance removed from the other part(s)

Example: Remote reservoir

f. **Steering gear**—Mechanism that moves (steers) the vehicle's wheels

Objective 2

Purposes of power steering systems

a. To increase steering response

b. To increase steering control

c. To decrease operator's steering effort

Note: Light manual effort is required to overcome hydraulic control valve. Power steering systems also have a means of manual override in case of hydraulic failure.

Objective 3

Basic components of a power steering assembly and their functions

a. **Reservoir**—Holds the power steering fluid

b. **Power steering pump**

- Takes power steering fluid from the reservoir and sends it to the power steering gear to aid the steering effort and then returns excess fluid back to the reservoir
- Converts mechanical energy from the engine into hydraulic energy to give power to the steering system

Note: The power steering pump is the "heart" of the system.

c. **Power steering gear** (piston/cylinder)

- Assists the mechanical steering with hydraulic fluid under pressure directed to one or the other side of the piston (depending on whether a right or left turn is being made)
- Converts hydraulic energy into mechanically-assisted energy

d. **Valves**

- Flow control valve—Regulates the constant flow of fluid from the pump as it varies with the demands of the steering gear
- Pressure relief (poppet) valve—Limits the hydraulic pressure built up when the steering gear is turned against its stops; relieves excess pressure

Note: These two functions are commonly combined into one valve.

e. **Power steering lines**—Conduct hydraulic fluid from reservoir to pump, through rest of system to power steering gear, and then back to reservoir

Note: Other components may be added depending on the manufacturer. An example of an optional component is the power steering cooler which is used to cool the power steering fluid.

Objective 4

Basic differences between manual steering and power steering

a. Power steering takes power from the engine to assist in the turning effort. Manual steering relies only on the driver's effort to operate the steering gear.

b. Power steering and manual steering have the same basic components (steering wheel, steering column, steering gear), but power steering adds hydraulic lines and the hydraulic pump to deliver hydraulic fluid under pressure to the steering gear.

Objective 5

Common types of power steering systems

a. **Integral power steering system**—All power steering components are contained in a compact gear box

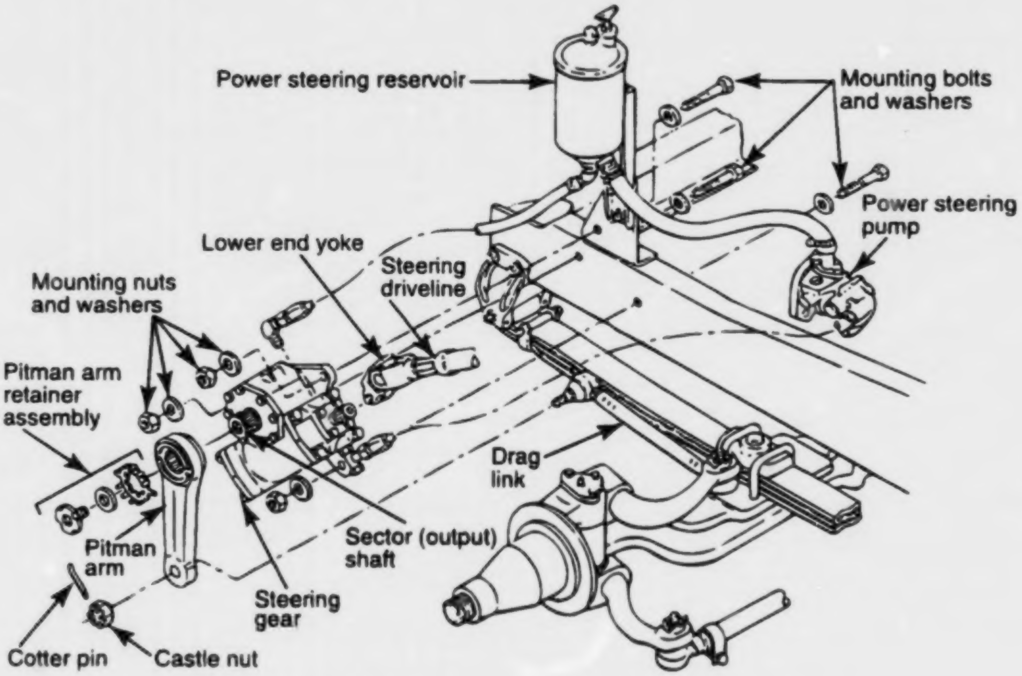
b. **Semi-integral steering system**—Consists of a gear box (manual steering mechanism and hydraulic control valve) with hydraulic lines connected to remote hydraulic power cylinder(s)

Note: These are the two most common types of power steering systems. Variations and other types may also be found on old and new equipment. Always check with the manufacturer for specific information.

Objective 6

Parts of an integral power steering system

Figure 1

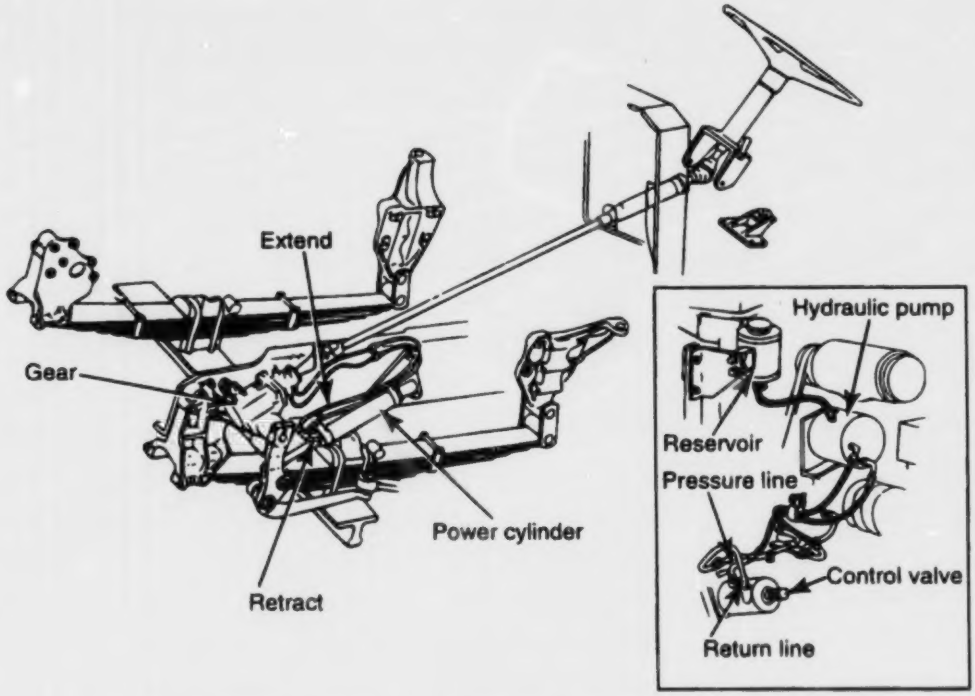

Power steering reservoir
Mounting bolts and washers
Power steering pump
Lower end yoke
Steering driveline
Mounting nuts and washers
Pitman arm retainer assembly
Drag link
Pitman arm
Sector (output) shaft
Steering gear
Cotter pin
Castle nut

Courtesy of Freightliner Corporation

Objective 7

Parts of a semi-integral power steering system

Figure 2


Extend
Gear
Power cylinder
Retract
Hydraulic pump
Reservoir
Pressure line
Control valve
Return line

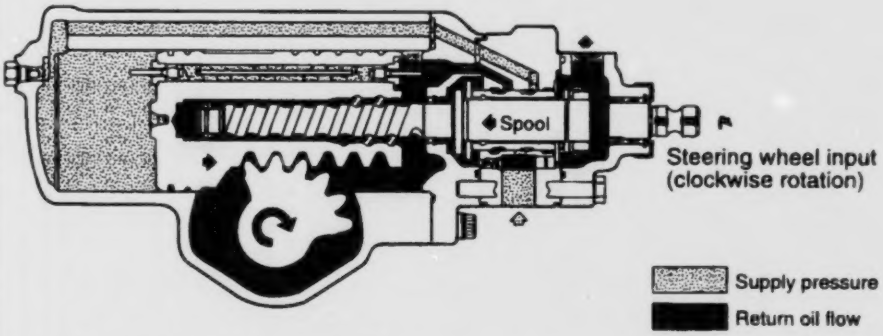
Courtesy of General Motors Corporation, Service Technology Group

Objective 8

Power steering operation flow

a. Gear operation for right turn

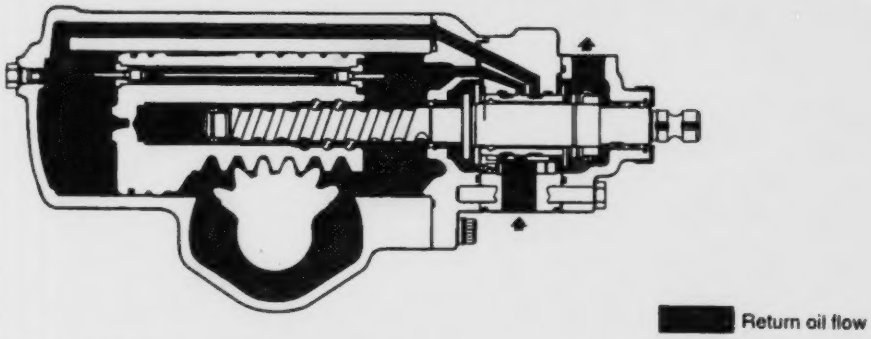
Figure 3


Spool
Steering wheel input (clockwise rotation)
Supply pressure
Return oil flow

Courtesy of TRW Commercial Steering Division

b. Gear in neutral (no steering action)

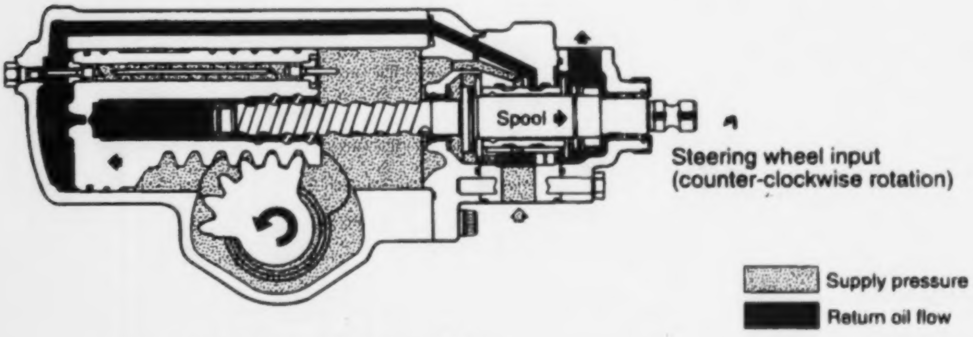
Figure 4


Return oil flow

Courtesy of TRW Commercial Steering Division

c. Gear operation for left turn

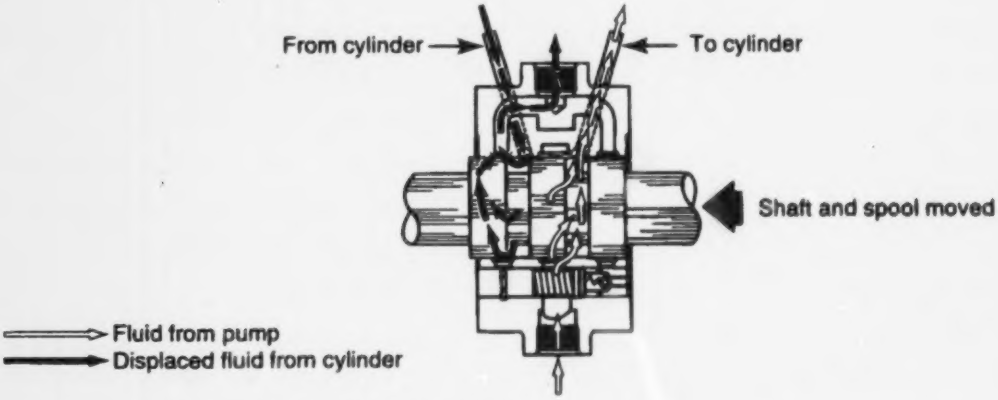
Figure 5


Spool
Steering wheel input (counter-clockwise rotation)
Supply pressure
Return oil flow

Courtesy of TRW Commercial Steering Division

d. Valve position and fluid flow for right turn

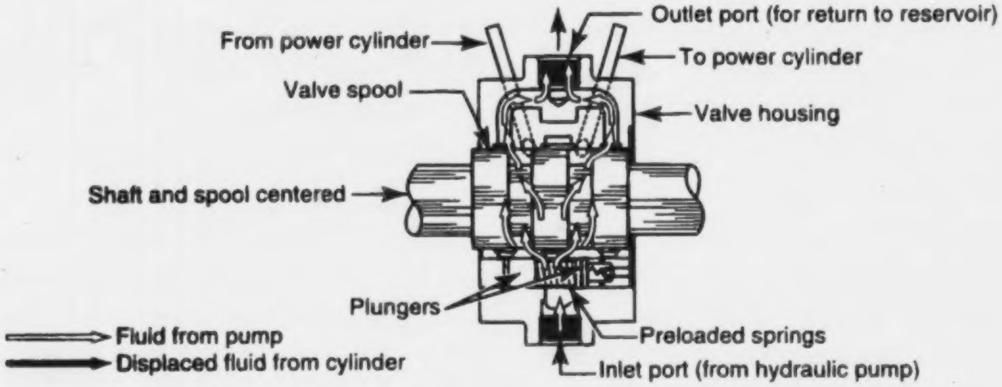
Figure 6


From cylinder
To cylinder
Shaft and spool moved
Fluid from pump
Displaced fluid from cylinder

Courtesy of TRW Commercial Steering Division

e. Neutral valve position and fluid flow

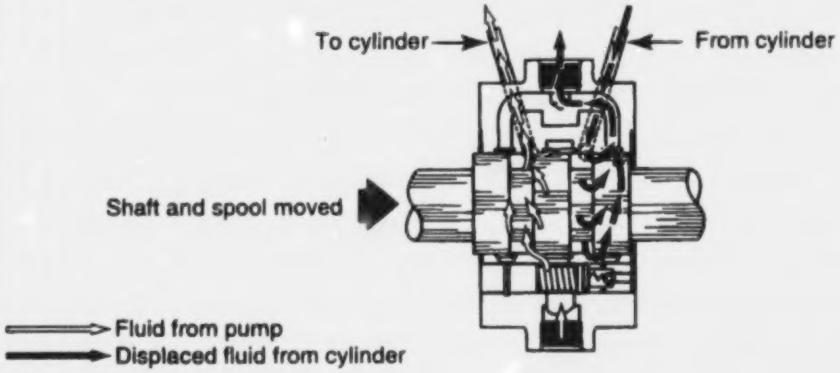
Figure 7


Outlet port (for return to reservoir)
From power cylinder
To power cylinder
Valve spool
Valve housing
Shaft and spool centered
Plungers
Preloaded springs
Fluid from pump
Displaced fluid from cylinder
Inlet port (from hydraulic pump)

Courtesy of TRW Commercial Steering Division

f. Valve position and fluid flow for left turn

Figure 8


To cylinder
From cylinder
Shaft and spool moved
Fluid from pump
Displaced fluid from cylinder

Courtesy of TRW Commercial Steering Division

Objective 9 **Common types of lubricants used in power steering systems**

a. Multiviscosity motor oil (10W40)

b. Dexron III (automatic transmission fluid)

c. Power steering fluid (type recommended by vehicle manufacturer)

Objective 10

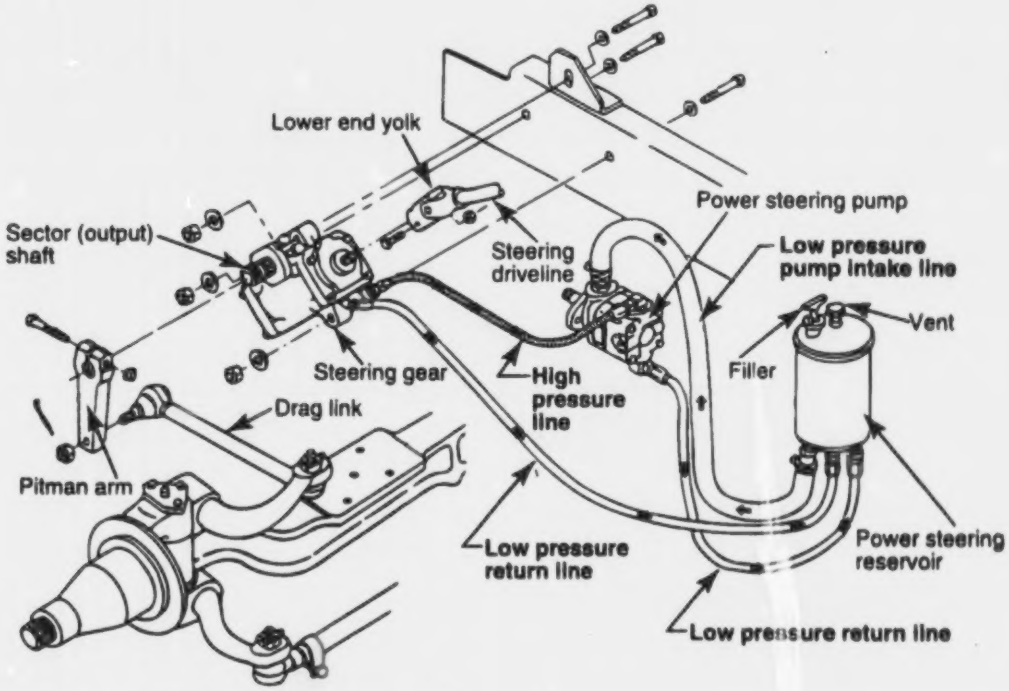
Types of lines used on power steering assemblies

a. **Low pressure line**—For suction and return line from gear or valve back to reservoir; fiber- or cloth-reinforced line

- Pump intake line—From reservoir to pump
- Return lines—From steering gear or pump back to reservoir

b. **High pressure line**—From pump to steering gear or valve; for delivering pressurized hydraulic fluid; wire-reinforced line

Figure 9


Lower end yolk
Power steering pump
Sector (output) shaft
Steering driveline
Low pressure pump intake line
Vent
Filler
Steering gear
High pressure line
Drag link
Pitman arm
Low pressure return line
Power steering reservoir
Low pressure return line

Courtesy of Freightliner Corporation

Objective 11

Types of power steering reservoirs

a. Built onto the pump

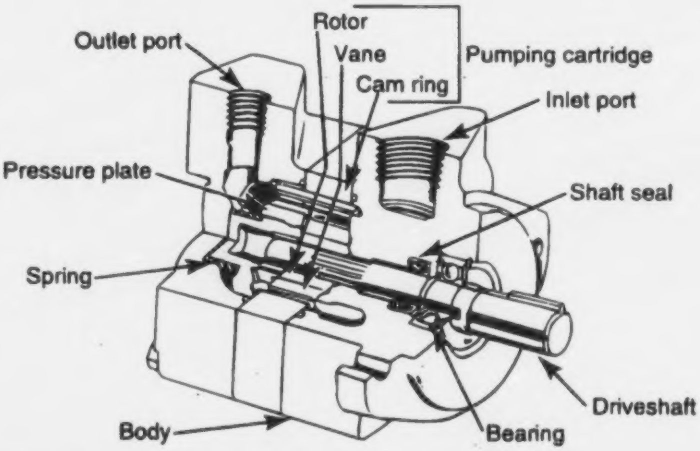
b. Remotely mounted

Objective 12

Types of hydraulic pumps used on power steering systems

a. **Vane pump**—Uses vanes (sliding blades) to transmit power steering fluid from hydraulic pump's intake port to outlet port

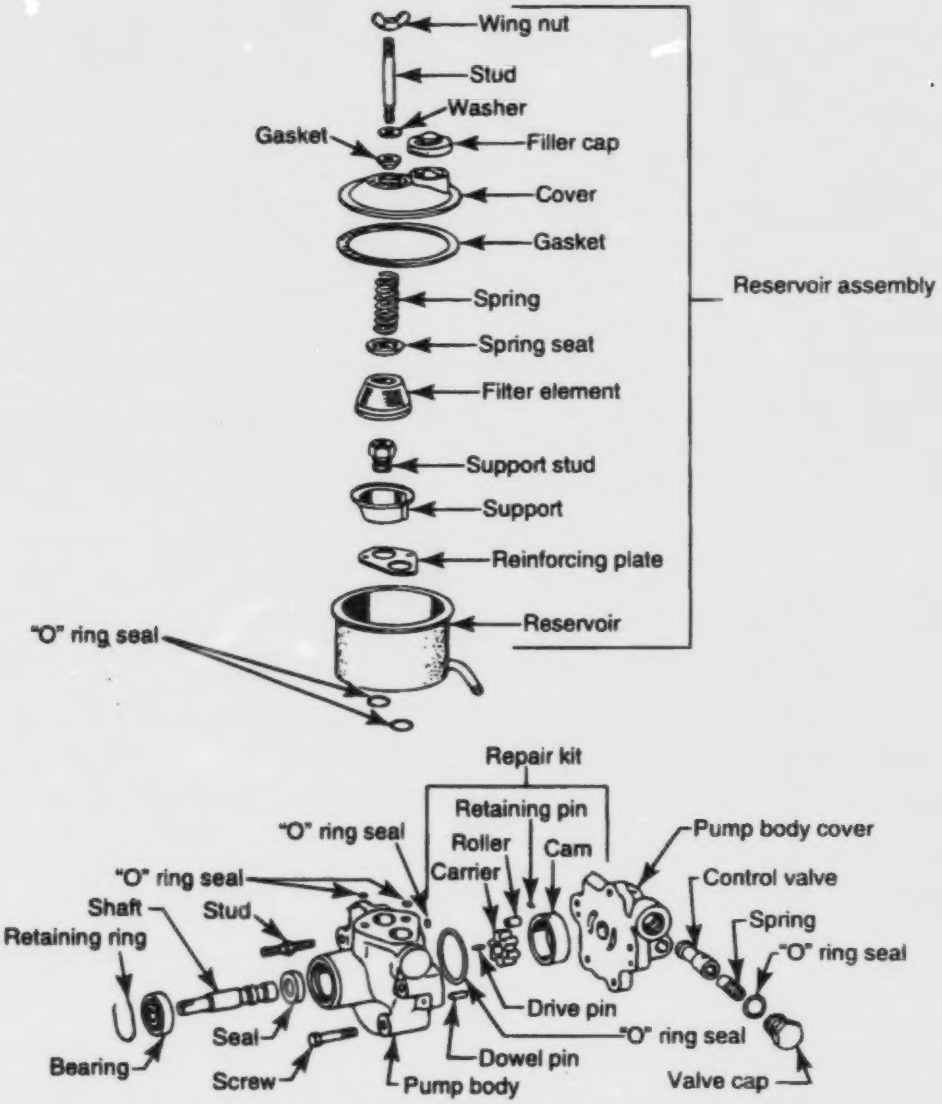
Figure 10


Rotor
Outlet port
Vane
Pumping cartridge
Cam ring
Inlet port
Pressure plate
Shaft seal
Spring
Driveshaft
Body
Bearing

Courtesy of Freightliner Corporation

b. **Roller pump**—Uses rollers to transmit power steering fluid from hydraulic pump's intake port to outlet port

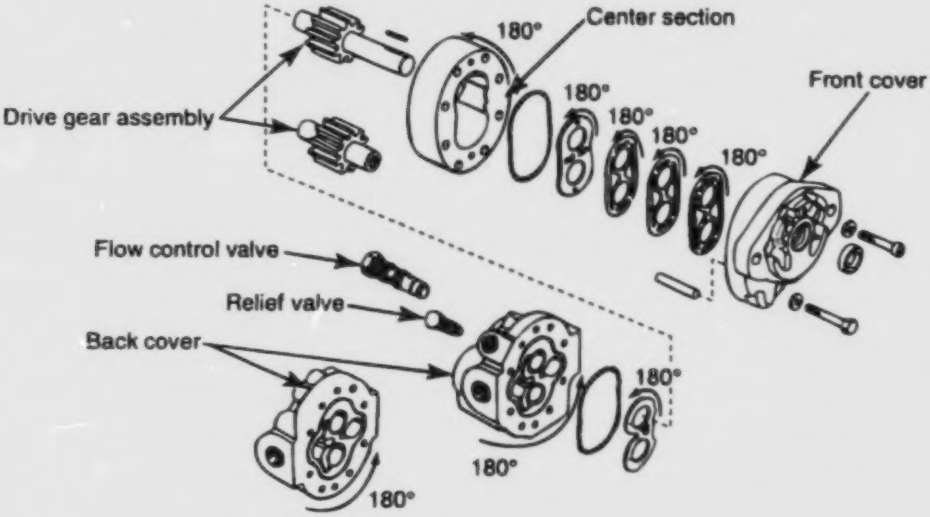
Figure 11


Wing nut
Stud
Washer
Gasket
Filler cap
Cover
Gasket
Spring
Spring seat
Filter element
Support stud
Support
Reinforcing plate
Reservoir
Reservoir assembly
"O" ring seal
Repair kit
Retaining pin
"O" ring seal
Roller
Cam
Pump body cover
Carrier
Control valve
"O" ring seal
Shaft
Stud
Spring
Retaining ring
"O" ring seal
Drive pin
"O" ring seal
Seal
Dowel pin
Bearing
Screw
Pump body
Valve cap

Reproduced from Motor Truck and Diesel Repair Manual © 1979 by permission of the Hearst Corporation.

c. **Gear pump**—Uses gears to transmit power steering fluid from hydraulic pump's intake port to outlet port

Figure 12


Center section
180°
Front cover
Drive gear assembly
180°
180°
180°
180°
Flow control valve
Relief valve
Back cover
180°
180°
180°

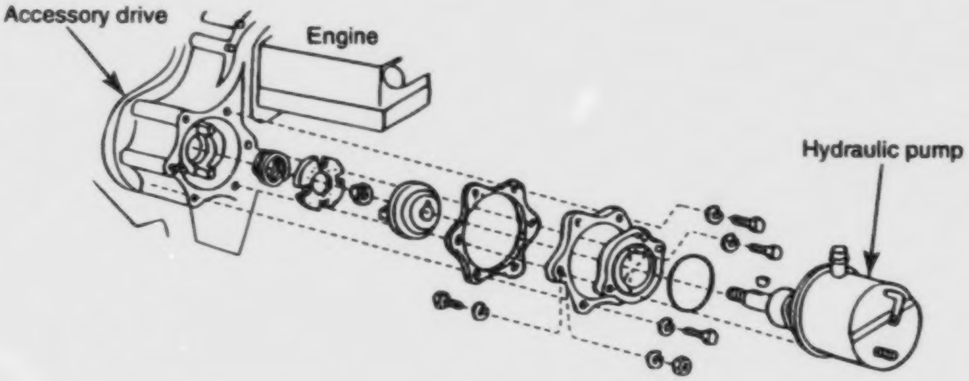
Courtesy of Navistar International Transportation Corp.

Objective 13

Means of mounting power steering pumps

a. **Direct mounted**—Gear drive type on engine accessory drive

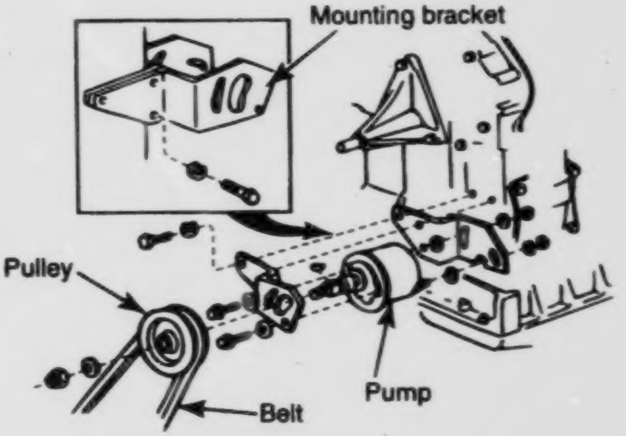
Figure 13


Accessory drive
Engine
Hydraulic pump

Courtesy of General Motors Corporation, Service Technology Group

b. **Remote mounted**—Belt drive type off engine's accessory pulley

Figure 14


Mounting bracket
Pulley
Pump
Belt

Courtesy of General Motors Corporation, Service Technology Group

Objective 14 | Common pump problems and possible causes

Problems	Possible causes
Steering pump leaks	— Damaged hoses, loose or damaged fittings — Leaking seals
Fluid being forced out of steering reservoir	— Temperature too high — Clogged filter in reservoir — Air in system — Pump is damaged
Fluid foaming in reservoir	— Temperature too high — Unapproved fluid used — Air in system — Pump is damaged
Fluid is milky (white)	— Water has entered reservoir through vent
Fluid is discolored or smells burned	— Temperature too high — Interval between fluid changes is too long — Unapproved fluid used
Low or no fluid from pump	— Pump driving in wrong direction—installed incorrectly or installed wrong pump — Pump shaft, drive gear, or coupling sheared or disengaged — Clogged filter in reservoir — Low fluid in system — Pumping element rollers stuck in carrier slots — Relief valve stuck open — Worn pump parts, causing internal leakage
Abnormal or too much noise	— Fluid lines contacting other vehicle parts — Loose parts — Air in system or low fluid level — Foreign material in system — Worn or damaged pump

Objective 15

Job Sheet 1—Diagnose, Test, and Troubleshoot Problems on a Power Steering System

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Driver/operator is asked to state problem	______
• Technician operates system to check out problem	______
• Work order, findings, repairs, and parts are listed on repair job ticket	______
• Cleanup is adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—One is included or use appropriate one provided at your facility
- Hydraulic power steering tester
- Power steering system to be worked on—assigned by instructor
- Others—as recommended by instructor and equipment service manual

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual or troubleshooting guide. The nine basic steps to troubleshoot the system include the following:

  ☐ a. Ask the driver/operator to state the problem clearly and concisely.

  ☐ b. Operate the equipment with the driver/operator to identify the problem.

  ☐ c. Inspect the vehicle/equipment to gather and organize facts.

  ☐ d. Use troubleshooting guide to list the probable causes.

- ☐ e. Reach a conclusion and start with most probable cause.
- ☐ f. Communicate with owner/operator about your conclusion.
- ☐ g. Make repairs as directed and approved.
- ☐ h. Test and operate equipment.
- ☐ i. Follow-up with driver/operator to make sure problem has been corrected.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____________________________________

____

____

444

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ______________________
Address ______________________
Phone # ______________________

Date In ____________
Date Out ____________

JOB TICKET

Customer Name ______________________
Customer Address ______________________
Customer Phone # ______________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ______________________

Services/repairs made: ______________________

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

______________________ Date ____________

Technician ____________
Supervisor ____________

Objective 16

Job Sheet 2—Remove and Repair/Replace Power Steering Gear

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Proper tools are used	______
• Service manual is used properly	______
• Proper steps are followed	______
• Job ticket is filled out properly	______
• Cleanup is adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—One is included or use appropriate one provided at your facility
- Torque wrench
- Power steering system (integral or semi-integral) to be worked on—assigned by instructor
- Others—as recommended by instructor and equipment service manual

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Disconnect drag link from pitman arm.

☐ 4. Remove pitman arm.

☐ 5. Disconnect steering driveline.

☐ 6. Disconnect power steering lines.

☐ 7. Remove steering gear.

☐ 8. Inspect and clean parts as needed.

☐ 9. Have instructor check your work so far. Discuss repairs/replacements needed.

Bench check ______________

☐ 10. Obtain instructor's and customer's approval for repairs/replacements to be made. Have them sign job ticket.

☐ 11. Repair or replace parts as approved. Record on job ticket.

☐ 12. Make adjustments as required.

☐ 13. Have instructor check your work.

Final check ______________

☐ 14. Turn in job ticket when finished.

☐ 15. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________________
Address ____________________
Phone # ____________________

Date In ____________
Date Out ____________

JOB TICKET

Customer Name ____________________
Customer Address ____________________
Customer Phone # ____________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________________

Services/repairs made: ____________________

	LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________________ Date ____________

Technician ____________
Supervisor ____________

Objective 17

Job Sheet 3—Rebuild Power Steering Gear

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Proper tools are used	______
• Service manual is used properly	______
• Proper steps are followed	______
• Job ticket is filled out properly	______
• Cleanup is adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—One is included or use appropriate one provided at your facility
- Torque wrench
- Power steering gear to be worked on—assigned by instructor
- Others—as recommended by instructor and equipment service manual

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Disconnect links and lines to get to power steering gear.

☐ 4. Disassemble parts.

☐ 5. Inspect and clean parts.

☐ 6. Have instructor check your work so far. Discuss replacements and rebuilding needed.

Bench check ______________

☐ 7. Obtain instructor's and customer's approval for replacements and rebuilding to be done. Have them sign job ticket.

☐ 8. Rebuild steering gear and replace worn parts as approved. Record on job ticket.

☐ 9. Reassemble parts.

☐ 10. Make adjustments as required.

☐ 11. Have instructor check your work.

Final check ______________

☐ 12. Turn in job ticket when finished.

☐ 13. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________

Address ____________

Phone # ____________

Date In ____________

Date Out ____________

JOB TICKET

Customer Name ____________

Customer Address ____________

Customer Phone # ____________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________

Services/repairs made: ____________

	LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________ Date ____________

Technician ____________

Supervisor ____________

Objective 18

Job Sheet 4—Remove and Replace Power Steering Pump; Adjust Belt if Used

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Proper tools are used	______
• Service manual is used properly	______
• Proper steps are followed	______
• Job ticket is filled out properly	______
• Cleanup is adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—One is included or use appropriate one provided at your facility
- Torque wrench
- Power steering fluid
- New power steering reservoir filter
- Power steering pump to be worked on—assigned by instructor
- Others—as recommended by instructor and equipment service manual

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Drain reservoir and disconnect and drain lines.

☐ 4. Remove mounting bolts from power steering pump.

☐ 5. Remove pump.

☐ 6. Inspect and clean parts as needed.

☐ 7. Have instructor check your work so far. Discuss repairs/replacements needed.

Bench check ______________

☐ 8. Obtain instructor's and customer's approval for repairs/replacements to be made. Have them sign job ticket.

☐ 9. Replace pump with new or rebuilt one as approved. Record on job ticket.

☐ 10. Remount and reconnect lines.

☐ 11. Adjust belt if belt driven.

☐ 12. Bleed and fill system. (See service manual and Job Sheet 7 for more information.)

☐ 13. Check operation.

☐ 14. Have instructor check your work.

Final check ______________

☐ 15. Turn in job ticket when finished.

☐ 16. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE
TOTAL PARTS/MATERIALS		

SPECIFICATIONS CHECKED

School/Work Name ______________________
Address ______________________
Phone # ______________________

Date In ______________
Date Out ______________

JOB TICKET

Customer Name ______________________
Customer Address ______________________
Customer Phone # ______________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ______________________

Services/repairs made: ______________________

	LABOR

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

______________________ Date ______________

Technician ______________
Supervisor ______________

Objective 19

Job Sheet 5—Inspect, Clean, Disassemble, and Rebuild Power Steering Pump; Replace Worn Parts

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Proper tools are used	______
• Service manual is used properly	______
• Proper steps are followed	______
• Job ticket is filled out properly	______
• Cleanup is adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—One is included or use appropriate one provided at your facility
- Torque wrench
- Used power steering pump to be worked on—assigned by instructor
- Others—as recommended by instructor and equipment service manual

Procedure

Note: The power steering pump should already be removed prior to beginning this job sheet.

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Inspect pump for leaks.

☐ 4. Clean pump.

☐ 5. Disassemble pump.

☐ 6. Inspect and clean parts as needed.

☐ 7. Have instructor check your work so far. Discuss repairs/replacements needed.

Bench check _______________

☐ 8. Obtain instructor's and customer's approval for repairs/replacements to be made. Have them sign job ticket.

☐ 9. Polish and rebuild parts and replace worn parts as approved. Record on job ticket.

☐ 10. Reassemble pump.

☐ 11. Check for correct operation.

☐ 12. Have instructor check your work.

Final check _______________

☐ 13. Turn in job ticket when finished.

☐ 14. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ______
Address ______
Phone # ______

Date In ______
Date Out ______

JOB TICKET

Customer Name ______
Customer Address ______
Customer Phone # ______

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ______

Services/repairs made: ______

	LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

______ Date ______

Technician ______
Supervisor ______

Objective 20

Job Sheet 6—Test and Repair/Replace Flow Control/Pressure Relief Valve(s) on Power Steering Pump

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Proper tools are used	______
• Service manual is used properly	______
• Proper steps are followed	______
• Job ticket is filled out properly	______
• Cleanup is adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—One is included or use appropriate one provided at your facility
- Power steering analyzer
- Torque wrench
- Flow control/pressure relief valve(s) to be worked on—assigned by instructor
- Others—as recommended by instructor and equipment service manual

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Clean off the control valve assembly.

Note: This is commonly mounted on the pump, but it may be a separate unit.

☐ 4. Hook up the power steering analyzer.

☐ 5. Test the flow control/pressure relief valve's performance with equipment's oil at operating temperature.

> Caution: Do not leave the valve closed for longer than 5 seconds since this could damage the power steering system.

☐ 6. Have instructor check your work so far. Discuss repairs/replacements needed.

Bench check _______________

☐ 7. Obtain instructor's and customer's approval for repairs/replacements to be made. Have them sign job ticket.

☐ 8. Remove flow control/relief valve and repair or replace as approved. Record on job ticket.

☐ 9. Have instructor check your work.

Final check _______________

☐ 10. Turn in job ticket when finished.

☐ 11. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________________

Address ____________________

Phone # ____________________

Date In ____________________

Date Out ____________________

JOB TICKET

Customer Name ____________________

Customer Address ____________________

Customer Phone # ____________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________________

Services/repairs made: ____________________

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________________ Date ____________________

Technician ____________________

Supervisor ____________________

Objective 21

Job Sheet 7—Fill and Bleed the Power Steering System

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Proper tools are used	______
• Service manual is used properly	______
• Proper steps are followed	______
• Job ticket is filled out properly	______
• Cleanup is adequate	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—One is included or use appropriate one provided at your facility
- Torque wrench
- Power steering fluid
- Power steering reservoir filter
- Power steering system to be worked on—assigned by instructor
- Others—as recommended by instructor and equipment service manual

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

> Caution: While performing steps 3-9, do NOT turn the steering wheel which would cause air to enter the system and make bleeding the system more difficult and time-consuming.

☐ 3. Make sure system has lines that are correctly connected with properly tightened fittings, new reservoir filter installed, and new fluid in reservoir.

☐ 4. Disconnect the fluid pressure line from the power steering gear, and place the end of it in a container of at least 2-quart (2-liter) capacity. Cap the steering gear fitting.

☐ 5. Crank the engine for ten seconds without allowing it to start. If it does start, shut it down immediately. Check the reservoir, and fill it as needed. Don't allow the reservoir fluid level to drop more than 2 inches (5 cm) below the full mark or air can enter the system.

☐ 6. Repeat step 5 until a stream of fluid is forced from the pressure line, indicating that the pump has been primed.

☐ 7. Connect the pressure line to the steering gear. Tighten the fitting nut until resistance is felt; then, tighten it one-sixth turn more.

☐ 8. Start the engine and let it idle for two minutes, without turning the steering wheel!

☐ 9. Shut the engine off, and check the reservoir fluid level. Fill the reservoir as needed.

☐ 10. Start the engine again. Now turn the steering wheel from full-left to full-right several times. Fill the reservoir as needed.

> Caution: Don't hold the wheel in the full-left or full-right position more than five seconds which could overheat the fluid and pump.

☐ 11. Check the system for leaks.

☐ 12. Have instructor check your work so far. Discuss repairs/replacements needed.

Bench check ________________

☐ 13. Obtain instructor's and customer's approval for repairs/replacements to be made. Have them sign job ticket.

☐ 14. Repair or replace leaking hoses and loose fittings as approved. Record on job sheet.

☐ 15. Repeat process to make sure system operates correctly.

☐ 16. Have instructor check your work.

Final check ________________

☐ 17. Turn in job ticket when finished.

☐ 18. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________________
Address ____________________
Phone # ____________________

Date In ____________
Date Out ____________

JOB TICKET

Customer Name ____________________
Customer Address ____________________
Customer Phone # ____________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________________

Services/repairs made: ____________________

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________________ Date ____________

Technician ____________
Supervisor ____________

Unit Contents

Student Components

Student Page

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Information Sheet 3B-5

Assignment Sheet

1—Select Wheel Bearings and Seals 3B-19

Job Sheets

1—Remove, Inspect, Clean, Replace, and Adjust Wheel Bearings and Seals 3B-21
2—Repair or Replace Steering Knuckle Assembly 3B-25
3—Inspect and Replace Tie Rod Ends 3B-29
4—Diagnose and Troubleshoot the Steering Axle Assembly 3B-33

Unit 3-B Steering Axle Components

Objective Sheet

Unit Objective

After completing this unit, the student should be able to repair, replace, and troubleshoot steering axle components. The student should demonstrate these competencies by completing the assignment sheet and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to steering axle components with their definitions.
2. Identify steering axle components.
3. Complete statements concerning steering linkage.
4. Identify the parts of a steering knuckle assembly.
5. Distinguish between lubricants used on steering axle components.
6. Complete a chart of typical steering axle problems and causes.
7. List purposes of wheel bearings.
8. Identify the parts of a wheel bearing.
9. Match wheel bearing defects with the correct descriptions.
10. Complete statements concerning guidelines for servicing wheel bearings.
11. Distinguish between correct and incorrect guidelines for adjusting wheel bearings.
12. List purposes of wheel seals.
13. List types of wheel seals.
14. Complete statements concerning guidelines for installing wheel seals.
15. Select wheel bearings and seals. (Assignment Sheet 1)
16. Remove, inspect, clean, replace, and adjust wheel bearings and seals. (Job Sheet 1)
17. Repair or replace a steering knuckle assembly. (Job Sheet 2)
18. Inspect and replace tie rod ends. (Job Sheet 3)
19. Diagnose and troubleshoot the steering axle assembly. (Job Sheet 4)

Information Sheet

Objective 1

Terms and definitions

a. **Bearing**—Part that helps spread the forces of a load to reduce the friction and wear of a moving part

b. **Drag link**—Cast rod or tube connecting the pitman arm to the steering knuckle assembly

c. **Endplay**—Amount of lateral movement of the hub along the spindle due to clearance in the bearings

d. **Journal**—That part of a shaft, axle, or spindle that turns in a bearing

e. **Kingpin**—Pin connecting the axle to the spindle

f. **Packing**—Act of forcing grease into wheel bearings

g. **Pitman arm**—Arm that connects steering gear to drag link

h. **Preload**—Adjustment of bearings so that there is a slight load on them to ensure proper internal alignment and limiting of endplay

i. **Press fit**—Tight fit between mating parts; must be "pressed" into place

j. **Races**—Tracks or channels in which something rolls or slides

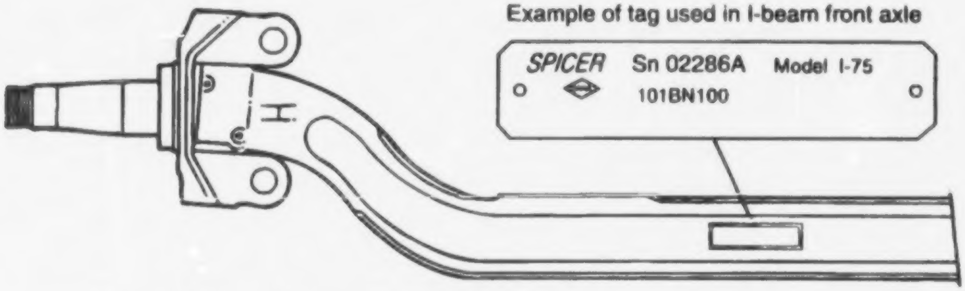
k. **Seal**—Material used to form a leak proof connection between moving or fixed parts

l. **Spindle**—Small shaft or axle on which a wheel turns; also called steering knuckle

m. **Steering axle**—Heat-treated forged steel I-beam with integral spring seats

Note: The steering axle is typically the front axle. It is rated and identified with a tag located between spring pads on the front side of center beam section. See Figure 1 for example of tag.

Figure 1



Example of tag used in I-beam front axle

Courtesy of Navistar International Transportation Corp.

n. **Tie rods** (cross tubes)—Metal connecting bars that are threaded with left and right hand end threads which provide for toe-in adjustment

o. **Tie rod assembly**—Three-piece construction, consisting of a tie rod and two tie rod end assemblies; the ends are threaded to the rod and locked with clamp bolts

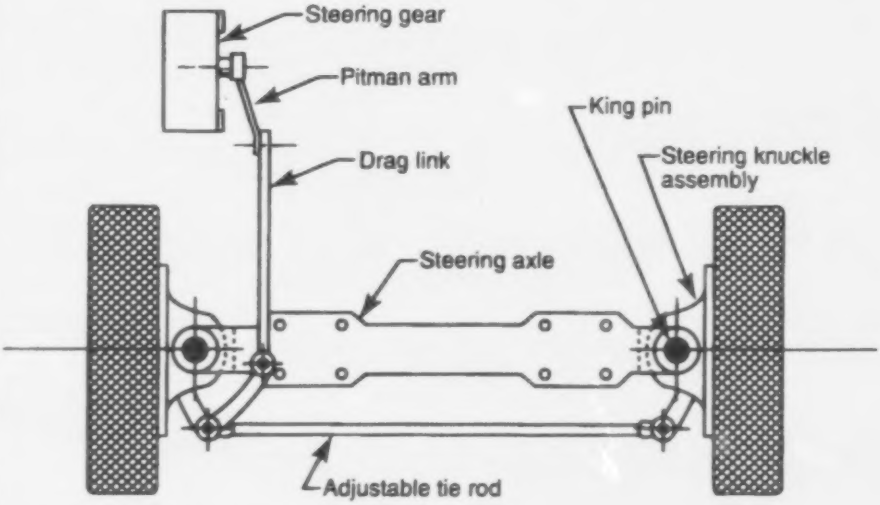
p. **Wheel and hub assembly**—Assembly consisting of tire, rim, hub, bearings, and other components mounted on an axle in such a way that it rotates to allow movement of a vehicle

q. **Wheel bearing**—Bearing used to distribute the load of a vehicle on its axles

Objective 2

Typical steering axle components

Figure 2


Steering gear
Pitman arm
King pin
Drag link
Steering knuckle assembly
Steering axle
Adjustable tie rod

Courtesy of Navistar International Transportation Corp.

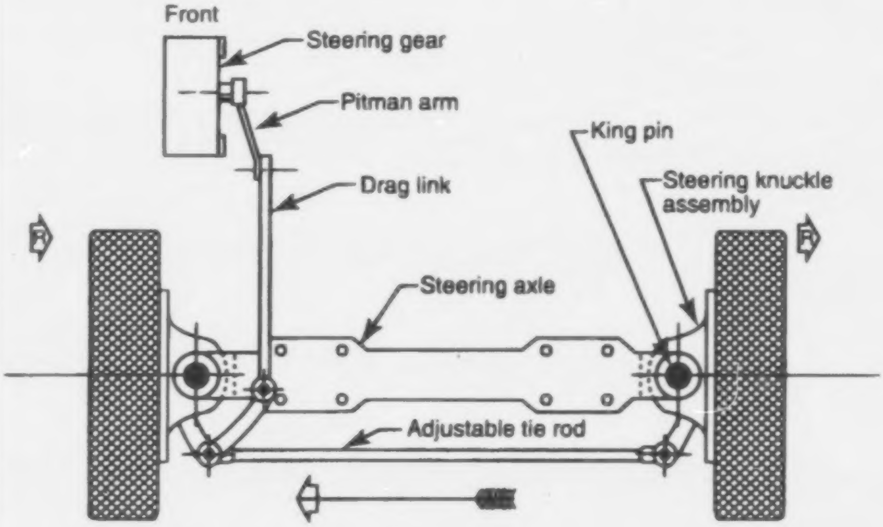
Objective 3

Steering linkage

a. Steering gear is connected to the drag link by the pitman arm

b. When steering gear is activated for right turn, the direction of steering linkage movement is right.

Figure 3


Front
Steering gear
Pitman arm
King pin
Drag link
Steering knuckle assembly
R
R
Steering axle
Adjustable tie rod

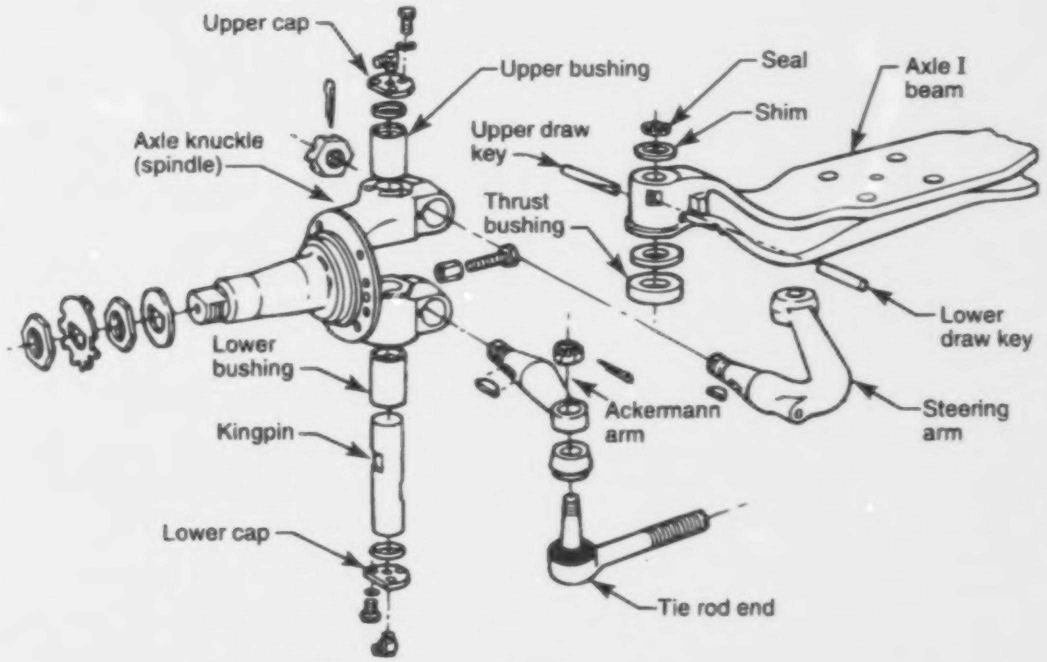
Courtesy of Navistar International Transportation Corp.

c. For left turn, the steering linkage would move to left.

Objective 4

Parts of a steering knuckle assembly (spindle assembly)

Figure 4


Upper cap
Upper bushing
Seal
Axle I beam
Shim
Axle knuckle (spindle)
Upper draw key
Thrust bushing
Lower draw key
Lower bushing
Steering arm
Ackermann arm
Kingpin
Lower cap
Tie rod end

Courtesy of Navistar International Transportation Corp.

Objective 5

Lubricants used on steering axle components

a. Multipurpose lithium grease meeting NLGI-1 or 2 specifications—For kingpins and tie rod ends (if equipped with lube fittings) and for grease-lubricated wheel bearings

b. Synthetic lubricants compatible with API GL-5—For oil-lubricated wheel bearings on heavy duty axles

c. Use the following guidelines for lubrication intervals or refer to the original equipment manufacturer's guidelines.

Table 1—Recommended maintenance schedule for on-highway use

INTERVAL	COMPONENT	PROCEDURE
Break-In After completing 100 hours or 4000 miles of operation	Wheel Bearings (All Models) Wheel Bearings (Oil) King Pins* Tie Rod Ends	Adjust Check level Lubricate with NLGI-1 or NLGI-2 (EP-1 or EP-2) Grease
4000 miles or monthly (whichever comes first)	Wheel Bearings (Oil)	Check level and fill with GL-5 Gear Lubricant
18,000 miles or every 5 months (whichever comes first)	King Pins* Tie Rod Ends	Lubricate with NLGI-1 or NLGI-2 (EP-1 or EP-2) Grease
30,000 miles or annually (whichever comes first)	Wheel Bearings (Grease)	Repack with NLGI-1 or NLGI-2 (EP-1 or EP-2) Grease
100,000 miles or annually (whichever comes first)	Wheel Bearings (Oil)	Change lubricant GL-5 Gear Lubricant

* Raise front axle wheels off the floor prior to lubrication of king pins. This allows sufficient grease to circulate through king pin bushings and thrust bearings.

Table 2—Recommended maintenance schedule for on/off highway use (low mileage/high hour operation)

INTERVAL	COMPONENT	PROCEDURE
Break-In After completing 100 hours or 1000 miles of operation	Wheel Bearings (All Models) Wheel Bearings (Oil) King Pins* Tie Rod Ends	Adjust Check level Lubricate with NLGI-1 or NLGI-2 (EP-1 or EP-2) Grease
1000 miles or monthly (whichever comes first)	Wheel Bearings (Oil)	Check level and fill with GL-5 Gear Lubricant
6,000 miles or every 6 months or 300 hrs. of operation (whichever comes first)	King Pins* Tie Rod Ends	Lubricate with NLGI-1 or NLGI-2 (EP-1 or EP-2) Grease
12,000 miles or annually or 600 hrs. of operation (whichever comes first)	Wheel Bearings (Grease)	Repack with NLGI-1 or NLGI-2 (EP-1 or EP-2) Grease
24,000 miles or annually or 100 hrs. of operation (whichever comes first)	Wheel Bearings (Oil)	Change lubricant GL-5 Gear Lubricant

* Raise front axle wheels off the floor prior to lubrication of king pins. This allows sufficient grease to circulate through king pin bushings and thrust bearings.

Low mileage / high hour conditions include stop and go, on / off highway, short haul operations, and usage of engine driven accessories.

Courtesy of Spicer/DANA

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Information Sheet

Objective 6 | **Typical steering axle problems and causes**

PROBLEMS	POSSIBLE CAUSES
Hard steering	1. Low tire pressure 2. Low pressure in power steering system 3. Improper front end alignment 4. Insufficient lubrication 5. Bent steering knuckle or linkage 6. Worn steering gear or linkage 7. Steering column misalignment
Loose steering	1. Steering gear out of adjustment 2. Worn tie rod ends
Truck wanders	1. Incorrect front end alignment 2. Broken spring 3. Tight steering gear or linkage 4. Loose spring shackles 5. Unequal tire inflation
Truck pulls to one side	1. Dragging brake 2. Tight or dry wheel bearing 3. Unequal tire inflation 4. Unequal caster (pulls to side with less caster)
Shimmy (low speed)	1. Incorrect front end alignment 2. Loose wheel bearings 3. Weak or broken springs 4. Worn tie rod ends 5. Worn knuckle pins or bushings 6. Worn shock absorber
Shimmy (high speed)	1. Unequal tire inflation 2. Wheels or tires eccentric or out-of-balance 3. Any of the possible causes for shimmy at low speed
Worn or broken steering ball stud	1. Drag link fasteners tightened past specified torque 2. Incorrect lubricant 3. Lack of lubrication 4. Power steering stops out-of-adjustment
Worn kingpins and knuckle bushings	1. Worn or missing seals and gaskets 2. Incorrect lubricant 3. Lack of lubrication or not following correct procedure or scheduled frequency

Courtesy of Navistar International Transportation Corp.

Objective 7

Purposes of wheel bearings

a. To spread the weight of the vehicle and its load over a greater surface

b. To reduce the friction of wheel rotation

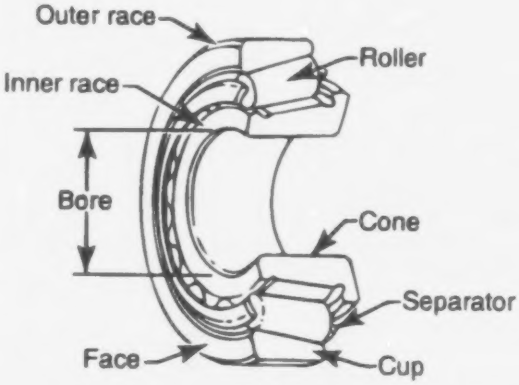
c. To reduce wear to parts

d. To provide a replaceable wear surface

Objective 8

Parts of a wheel bearing (tapered roller shown)

Figure 5


Outer race
Roller
Inner race
Bore
Cone
Separator
Face
Cup

Used with permission of Deere and Company, Moline, Illinois

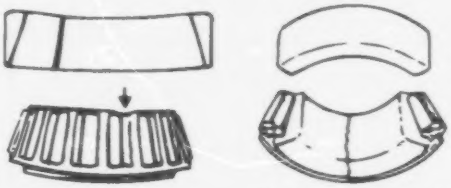
Objective 9

Wheel bearing defects

a. **Mechanical damage**—Deforming or breaking of the bearing assembly as a result of mechanical stress, such as rough handling or improper fit; the bearing must be replaced

Examples: Cracked, bent, or broken parts—cages, races, rollers, separators

Figure 6

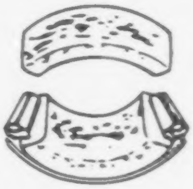


Bent cage

Cracked inner race

b. **Smearing**—Metal smears on the surface on the races due to slippage as a result of improper fit, poor lubrication, overloading, or rough handling; replace bearings

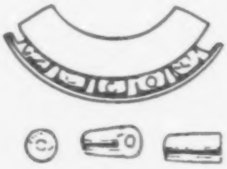
Figure 7



Smears

c. **Galling**—Metal smears on the ends of the rollers, usually caused by overheating from inadequate lubrication or overloading; the bearing must be replaced

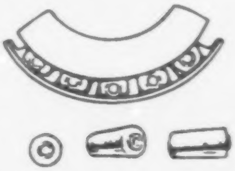
Figure 8



Galling

d. **Abrasive step wear**—Wear of the ends of the rollers due to fine particles in the lubricant; the bearing must be replaced if the wear is excessive or simply cleaned and repacked if wear is minor

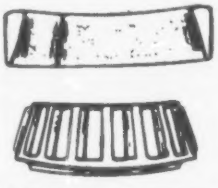
Figure 9



Abrasive step wear

e. **Abrasive roller wear**—Wear patterns on the rollers and race from contamination by the abrasives; bearing can be reused if wear is minor

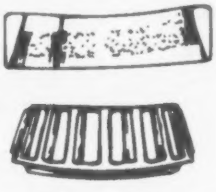
Figure 10



Abrasive roller wear

f. **Misalignment**—Improper fit of bearing assembly parts due to improper installation or excessive pressure from foreign object in the hub, usually evidenced by uneven wear of the races; the bearing must be replaced if the wear is excessive or if the bearing is damaged

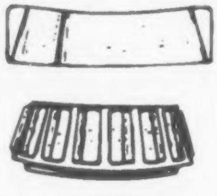
Figure 11



Misalignment

g. **Indentations**—Pits and scars on surfaces of races and rollers caused by contamination with large particles; clean and repack or replace if bearings are rough or noisy

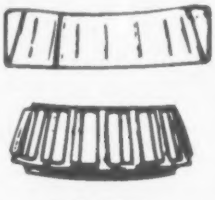
Figure 12



Indentations

h. **Brinelling**—Surface indentations in the raceway that parallel the rollers caused by excessive loading or vibration while the bearing is not rotating; generally requires replacement of the bearing

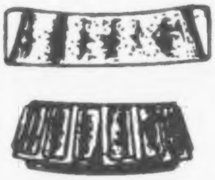
Figure 13



Brinelling

i. **Spalling**—Flaking of the surface metal from metal fatigue or poor quality bearings; replace bearings

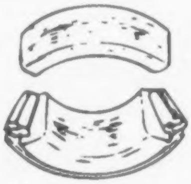
Figure 14



Fatigue spalling

j. **Frettage**—Corrosion and spotty wear caused by relatively small movements of poorly lubricated parts; replace bearings

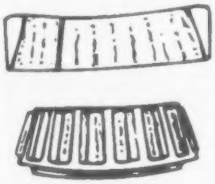
Figure 15



Frettage

k. **Etching**—Gray or black discoloration of race and roller surfaces, usually with scuffing of the surfaces in patterns parallel to the rollers and generally caused by loose fitting of the bearings; generally requires replacement of bearing

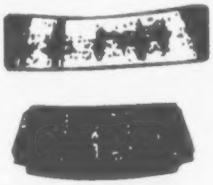
Figure 16



Etching

l. **Heat discoloration**—Discoloration ranging from faint yellow to dark blue as a result of inadequate lubrication or overloading; replace the bearings

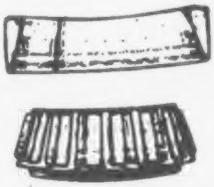
Figure 17



Heat discoloration

m. **Stain discoloration**—Discoloration ranging from light brown to black as a result of the use of the incorrect lubricant or contamination by moisture; reuse bearings if stain can be removed by light polishing and there is no evidence of overheating

Figure 18



Stain discoloration

Objective 10

Guidelines for servicing wheel bearings

a. Follow the vehicle manufacturer's recommendations for the selection and installation of wheel bearings.

Note: Compare the identification numbers of the old bearings and the replacement bearings. Do not destroy the old bearings until you record the identification numbers.

b. Follow the bearing manufacturer's instructions for the selection and installation of lubricant.

c. Follow the vehicle manufacturer's recommendations for wheel bearing service intervals.

d. Every wheel has two sets of bearings—an inner bearing assembly and an outer bearing assembly. Be sure you don't install these backwards.

e. Keep bearing assemblies together as a set and do not exchange parts between different assemblies.

f. Use only an approved solvent to clean bearings.

g. If compressed air is used to clean bearings, use only low pressure and never enough pressure that it causes the rollers to turn.

> Caution: A bearing may fly apart if high pressure compressed air is used.

h. Handle the bearings with care to prevent damage.

i. Observe asbestos exposure precautions because the removal and installation of wheel bearings may involve handling brake linings containing asbestos and other components contaminated with brake lining dust.

j. Do not reuse cotter pins removed from the spindle; always install a new cotter pin.

k. If the condition of a bearing, seal, or other component is in doubt, replace it.

l. Use the proper seal and be careful to install it correctly.

m. Pack grease-lubricated bearings using a pressure packer if possible or by hand if necessary.

Objective 11

Guidelines for adjusting wheel bearings

a. Follow vehicle service manual procedure to adjust bearings.

b. Adjustment of bearings with preload can cause premature bearing failure.

c. If recommended by service manual, use a dial indicator to adjust endplay.

d. Typical wheel bearing adjustment requires endplay of between .003" to .009" (.076 to .228 mm). Check service manual for specifications.

e. While adjusting bearings, make sure that brakes do not drag on drum or rotor to produce a false adjustment.

f. Make preliminary adjustment by tightening spindle (adjusting) nut to torque recommended by service manual.

g. Rotate wheel in both directions while tightening to ensure that bearing is seated.

h. To align locking device, back nut off spindle from initial torque setting by ⅙ to ⅓ turn (depending on manufacturer) to align with nearest locking hole. Wheel should rotate freely.

i. Do not reuse locking devices (cotter pins, washers with tangs, etc.) that are deformed during installation.

Objective 12

Purposes of wheel seals

a. To retain lubricants or liquids

b. To exclude dirt, water, and other contaminants

c. To separate dissimilar fluids (such as lubricating oil and water)

d. To confine pressure

Objective 13

Types of wheel seals

a. One-piece

- Unitized—Needs special driver
- Barrier—Installed with bare hand

b. Multipiece

- Lip seal—May have single or double lip
- Wear rings—May have flat ring or grit guard

Objective 14

Guidelines for installing wheel seals

a. Remove the old seal carefully. Take care when prying out the old seal not to scratch the housing. Sometimes you need a special puller.

b. Inspect the bore and shaft for nicks and burrs. File off any burrs that could cut the new seal.

c. Check shaft and bore dimensions to make sure they match the seal specifications.

d. Excessively worn or grooved shafts may be fitted with wear (repair) sleeves to create a new seal running surface. These require a special installation tool.

e. Never reuse old or damaged seals.

f. Make sure the new seal faces in the correct direction; usually the lip faces the lubricant or fluid to be retained.

g. Prelubricate the sealing element with the same lubricant being retained prior to installation.

h. Use the correct tool to install the seal. These include an arbor press, soft-face hammer, specially-made seal installer, or old bearing cup. Apply force evenly around the outer edge to avoid cocking the seal.

i. Check to see that the seal is fully seated and aligned in its bore. The manufacturer may specify how deep the seal must be installed.

j. Check and adjust the fluid level after installing a seal, and check for leaks.

Objective 15

Assignment Sheet 1—Select Wheel Bearings and Seals

Name ______________________ Overall Rating ________

Date ______________________

Evaluation Criteria	Rating
• Directions are followed	____
• Questions are answered correctly	____

Basic Skills

Reading Critical Thinking

Introduction

An important skill in the service of brakes and wheel assemblies is the replacement of bearings and seals. There are numerous sizes and designs of seals and bearings, but to do their job properly the installed seals and bearings must be the correct parts for the vehicle. This assignment will provide you with practice in selecting those parts.

Directions

Your instructor will assign you one or more vehicles, either actual vehicles in your facility or vehicles identified by make and model. Use resources available in your shop to determine the following information about the wheel bearings and seals for the assigned vehicles.

1. Front Wheels
   a. Bearings or bearing set part number(s) ______________________
   ____
   b. Recommended lubricant ______________________
   c. Seal part number ______________________
   d. Seal material ______________________
   e. Number of seal pieces ______________________
2. Rear Wheels
   a. Bearings or bearing set part number(s) ______________________
   ____________ ______________________
   b. Recommended lubricant ______________________
   c. Seal part number ______________________
   d. Seal material ______________________
   e. Number of seal pieces ______________________

Objective 16

Job Sheet 1—Remove, Inspect, Clean, Replace and Adjust Wheel Bearings and Seals

Name ________________________ Attempt Number ______

Date ________________________ Overall Rating ______

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Proper tools, hydraulic floor jack, wheel dolly are used	______
• Service manual is used properly	______
• Steps are followed	______
• Job ticket is filled out properly	______
• Proper bearing and seals procedures are used	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Hydraulic floor jack
- Wheel dolly (or jack stand)
- Wheel chocks
- Torque wrench
- Front wheel assembly to be worked on—assigned by instructor
- Others as recommended by instructor and equipment service manual

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Set parking brake and/or chock wheels so vehicle will not roll.

☐ 4. Raise wheel using a hydraulic floor jack.

☐ 5. Position wheel dolly under wheel to support the wheel. Make sure that wheel rotates freely.

☐ 6. Drain oil on models so equipped.

☐ 7. Remove hub cap.

☐ 8. Remove outer nut and lock assembly.

☐ 9. Pull the wheel assembly off of the spindle.

☐ 10. Inspect and clean parts.

☐ 11. Remove old bearings (inner and outer if needed.)

☐ 12. Have instructor check your work so far. Discuss replacements needed.

Bench check _______________

☐ 13. Oil parts.

☐ 14. Reassemble wheel on spindle using new parts as approved. Record on job ticket.

☐ 15. Adjust bearings as specified.

Caution: Do not adjust bearings with preload.

☐ 16. Have instructor check your work.

Final check _______________

☐ 17. Turn in job ticket when finished.

☐ 18. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE
TOTAL PARTS/MATERIALS		

SPECIFICATIONS CHECKED

School/Work Name ____________

Address ____________

Phone # ____________

Date In ________

Date Out ________

JOB TICKET

Customer Name ____________

Customer Address ____________

Customer Phone # ____________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________

Services/repairs made: ____________

	LABOR

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________ Date ________

Technician ________

Supervisor ________

Objective 17

Job Sheet 2—Repair or Replace Steering Knuckle Assembly

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Proper tools, hydraulic floor jack, wheel dolly are used	______
• Service manual is used properly	______
• Steps are followed	______
• Job ticket is filled out properly	______
• Proper bearing and seals procedures are used	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Hydraulic floor jack
- Wheel dolly (or jack stand)
- Wheel chocks
- Torque wrench
- Front wheel assembly to be worked on—assigned by instructor
- Others as recommended by instructor and equipment service manual

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Set parking brake and/or chock wheels so vehicle will not roll.

☐ 4. Raise wheel using a hydraulic floor jack.

☐ 5. Position wheel dolly under wheel to support the wheel. Make sure that wheel rotates freely.

☐ 6. Drain oil on models so equipped.

☐ 7. Remove wheel and hub assembly

☐ 8. Remove brake backing plate or caliper mounting bracket from the knuckle.

☐ 9. Remove tie rod assembly and drag link from steering arms using a suitable tool.

☐ 10. Inspect idler arm, bearings and bushings (if installed). Replace as needed.

☐ 11. Remove draw keys, top and bottom steering knuckle caps, and o-rings if used.

☐ 12. Drive out the kingpin. Do not heat I-beam to aid in removal of kingpin.

☐ 13. Remove steering knuckles, thrust bearings, and any spacer shims used.

☐ 14. Thoroughly clean all parts.

☐ 15. Remove old bushings.

☐ 16. Install new replacement bushings. Bronze bushings will also need to be reamed.

☐ 17. Have instructor check your work so far. Discuss replacements needed.

Bench check _______________

☐ 18. Install seals as specified.

☐ 19. Install steering knuckle, thrust bearing assembly, spacer shims as required, and kingpins. Refer to specifications for proper clearance required.

☐ 20. Connect linkage.

☐ 21. Install wheel.

☐ 22. Adjust wheel bearings as specified.

Caution: Do not adjust bearings with preload.

☐ 23. Have instructor check your work.

Final check ______________

☐ 24. Turn in job ticket when finished.

☐ 25. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ______

Address ______

Phone # ______

Date In ______

Date Out ______

JOB TICKET

Customer Name ______

Customer Address ______

Customer Phone # ______

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ______

Services/repairs made: ______

Services/repairs made	LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

______ Date ______

Technician ______

Supervisor ______

Objective 18

Job Sheet 3—Inspect and Replace Tie Rod Ends

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Proper tools, hydraulic floor jack, wheel chocks are used	______
• Service manual is used properly	______
• Steps are followed	______
• Job ticket is filled out properly	______
• Proper tie rod ends are in alignment and nuts and clamps are at proper torque	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Hydraulic floor jack
- Wheel dolly (or jack stand)
- Wheel chocks
- Torque wrench
- Front wheel assembly to be worked on—assigned by instructor
- Others as recommended by instructor and equipment service manual

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Inspect for looseness. If any is found, continue with rest of procedure.

☐ 4. Remove nut (and key if used) from the rod end.

☐ 5. Remove tie rod end stud from steering arm.

☐ 6. Replace tie rod end.

☐ 7. Reinstall assembly into steering arm and torque nut.

☐ 8. Check alignment on tie rod. Adjust as needed.

☐ 9. Have instructor check your work.

Final check _______________

☐ 10. Turn in job ticket when finished.

☐ 11. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

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PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ______

Address ______

Phone # ______

Date In ______

Date Out ______

JOB TICKET

Customer Name ______

Customer Address ______

Customer Phone # ______

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ______

Services/repairs made: ______

Services/repairs made	LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

______ Date ______

Technician ______

Supervisor ______

Objective 19

Job Sheet 4—Diagnose and Troubleshoot the Steering Axle Assembly

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Proper tools are used	______
• Steps in service manual's troubleshooting section are followed	______
• Job ticket is filled out properly on troubleshooting repair	______
• Assembly is properly diagnosed and recommended repairs are correct	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Hydraulic floor jack
- Wheel chocks
- Torque wrench
- Front wheel assembly to be worked on—assigned by instructor
- Others as recommended by instructor and equipment service manual

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Use the attached "Typical Diagnosis Checklist and Guide" to perform diagnosis on a problem area.

☐ 4. After completing checklist and guide, fill out the report on the job ticket and have findings checked with instructor for approval before making repairs.

Evaluator's Comments: ______________________________

____

____

Typical Diagnosis Checklist and Guide

Whenever steering complaints are encountered, it is important that the complete steering system be inspected. Special body or equipment installations should also be considered for their effect on steering performance.

The steering system consists of the power steering gear, a hydraulic supply pump with pressure and flow controls and an oil reservoir, the front axle and mechanical components, and the steering column or input shaft and connecting linkages. The front tires and wheels must also be considered as part of the total steering system.

Steering performance can be affected by out-of-line conditions anywhere in the total steering system. Other factors outside the steering system can also contribute to poor steering performance.

Many times a steering gear is removed and disassembled needlessly because an organized diagnosis procedure has not been followed.

☐ 1. **Define the complaint.**

  a. Talk to and question the driver.
  b. Drive the vehicle.

☐ 2. **Check overall vehicle.**

  a. Look for poor loading practices.
  b. Check tires for mismatch and proper air pressure.
  c. Check for dry fifth wheel or improper location.
  d. Check suspension for sagging or shifting. (Out-of-line rear axles will tend to steer the front end of the vehicle.)

☐ 3. **Check mechanical components.**

  a. Check all front axle components for wear, looseness, or seizure.
  b. Inspect front and rear suspension components.
  c. Check steering gear mounting to be sure it is tight and not shifting on the chassis or axle.
  d. Inspect steering column components.

☐ 4. **Check hydraulic supply system.**

  a. Evaluate hydraulic supply system performance.
  b. Check vehicle manufacturer's specifications for oil pressure and oil flow.

Note: Keep in mind that the same problems that upset manual steering will also affect power steering.

Steering Troubleshooting Guide

Symptom	Possible cause	Remedy
Oil leaking at output shaft of steering gear	Clogged oil filter in reservoir (high back pressure)	Replace filter Increase change frequency
	Pinched or restricted oil return line	Locate and correct Check back pressure
	Damaged quad ring seal	Replace quad ring seal
	Damaged bronze bearings	Replace Bronze bearings Polish output shaft or replace to remove bronze deposits
	Damaged lipseal	Replace with replacement seal assembly
	Damaged roller bearings	Replace roller bearings Polish output shaft or replace to remove pitting & grooving in seal area
Oil leaking at actuating shaft of steering gear	Worn or damaged oil seal	Replace seals
	Damaged actuating shaft seal surface	Replace damaged parts Lube bearing cap more often
Oil leaking at supply pump drive shaft	Damaged oil seal	Replace oil seal
	Oil seal-heat damaged	Check operating temperature
	Loose or damaged bushing on pump drive shaft	Repair pump per pump service instructions
Oil leaking between reservoir and pump body	Seal or gasket damaged	Replace damaged parts
Lubricant milky or white in appearance	Water entry through reservoir venting system	Clean vent system or replace cap assembly
Oil forced out of reservoir	Clogged oil filter	Change oil and oil filter Increase change intervals
	Loose pump drive belts	Adjust belts or replace
	Air in system	Bleed air from system Check for air leak on suction side of supply pump
	Faulty supply pump (Cavitation)	Check supply pump Repair pump per pump service instruction
	Relief plungers of steering gear not adjusted properly	Adjust relief plungers
	Operating temperatures too high	Check system and locate cause of overheating
Engine oil in power steering reservoir (Gear driven pump)	Faulty seal at pump drive shaft	Repair pump
	Faulty seal at accessory shaft driving supply pump	Repair accessory drive
Lubricating oil discolored or smells bad	Operating temperatures too high	Check and correct cause of overheating
	Change intervals too long	Increase oil change frequency
	Incorrect lubricant used	Drain, flush, and refill with 10W-40 motor oil

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Steering Troubleshooting Guide (Cont.)

Symptom	Possible cause	Remedy
High operating temperatures	Oil flow restriction Oil flow too high	Check back pressure Check maximum oil flow
Oil in reservoir — foaming	Air leak in suction side of supply pump Pump cavitating Oil overheating Incorrect lubricant	Refer to pump servicing instructions Check for restriction in pump supply See high operating temperatures Change to 10W-40 motor oil
No power steering on cold start	Hydraulic supply pump vanes not extending (Vane type pump only)	Increase engine speed momentarily to extend vanes and start pump action. Usually a temporary and infrequent occurrence and not cause for pump repair or replacement.
Excessive pump pressure with steering gear in neutral position	Pinched oil return line High back pressure Binding steering column Damaged actuating shaft bearing	Relocate line Repair steering column Replace damaged parts as required
Wheel cuts restricted	Relief plungers misadjusted	Adjust relief plungers
Erratic steering or no steering at all	Insufficient volume of oil being metered by flow divider to steering gear induced by foreign particles on flow divider valve, causing the valve to hang up in the bore	Polish flow divider valve to remove foreign particles and burrs Refer to pump servicing instructions
Hard Steering	Loose belts Worn pulley(s) due to belt slipping Faulty supply pump Front axle overloaded Faulty steering geometry High operating temperature	Tighten or replace belts Replace pulley(s) and belts (keep belt tight) Refer to pump servicing procedures Correct loading practices Align front end Locate and correct cause of overheating
Wheel steering hard in one or both directions	Bent or damaged king pins and tie rods Front end load too great for rated axle capacity Fatigued by-pass valve spring in pump Low oil level in steering system Air in system Caster and camber degree incorrect Metal or foreign material caught in actuating valve Actuating valve worn or chipped by dirt	Repair or replace king pins and tie rods Refer to servicing instructions Lighten load or install larger steering gear Replace with flow control valve assembly Refer to pump servicing instructions Fill oil reservoir as required Bleed system and check for cause of air Correct to specifications Remove actuating valve Clean and check parts for damage If damage is excessive replace damaged parts as required

Steering Troubleshooting Guide (Cont.)

Symptom	Possible cause	Remedy
Wheel steering hard in one direction	Broken reversing springs in steering gear	Replace reversing springs and damaged parts Refer to repair procedures to check for additional damage
	Metal or foreign material in relief ball seat in piston of steering gear	Remove piston and clean relief valve seats or replace damaged parts
	Foreign material in relief valve	Clean relief valve
Steering extremely light in one or both directions	Bent or damaged reversing springs	Check for impact or accident damage Replace damaged parts
Steering input not smooth (seizing, binding)	Worn universal joint	Check and replace as required
	Lack of lubrication	Lubricate per vehicle manufacturer's recommendations
	Universal joint not phased properly	See note, next page
	Low oil flow	Idle speed too slow Drive belts slipping Supply pump not to specifications
	Pump cavitating	Correct pump supply
	Overheating	Correct cause of overheating
Darting, wandering (oversteering)	Oil flow too high	Supply pump not to specifications
	Air trapped in steering gear	Bleed system
	Looseness, worn front end parts Front end alignment not correct	Check and repair as required Align front end — Caster
	Radial tire sidewall flex	Check tire pressure Check for out of line tread Contact tire manufacturer representative
	Excessive wear or damage in steering gear	Check and repair as required
	Overloading	Reduce loads
	Steering column u-joint phasing incorrect	See note, next page
	Mechanical bind in steering gear	Check steering gear mounting for distortion Check for damaged or distorted steering gear components
	Tight tie rod ends & drag link sockets	Check rotational torque & replace if necessary

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Steering Troubleshooting Guide (Cont.)

<table>
<tr><th>Symptom</th><th>Possible cause</th><th>Remedy</th></tr>
<tr><td colspan="3">Note: Universal Joints

Universal joints are designed to operate best when the angle between the drive and driven shafts is a maximum of 20 to 25 degrees. Angles greater than this will cause undesirable velocity changes between the two shafts. This velocity change may upset steering performance. When two universal joints are used, it is in most instances possible to phase the two joints to match a high and low velocity in a manner that will provide equal velocity between the drive and driven shafts. A third universal joint in the shaft arrangement can upset the phasing of the first two joints and it is important that this third joint's operating angle is limited to a maximum of 20-25 degrees.

Phasing of the universal joints in the steering column can be checked quite easily. Using an inch-pound graduated dial reading type torque wrench, read the variation in the torque reading while steering from lock-to-lock, with a socket on the steering shaft nut under the horn button. Variation of more than 15 in.-lb. indicates improper phasing. This reading is taken with the vehicle stationary and the engine running.

Phasing can usually be accomplished by rotating the two piece intermediate shaft one spline at a time until the torque reading remains the same all the way around the 360 degree rotation of the steering wheel.</td></tr>
<tr><td>Excessive backlash</td><td>Worn universal joint</td><td>Replace universal joint</td></tr>
<tr><td></td><td>Worn pins and keys universal joint to actuating shaft and universal joint to steering shaft</td><td>Replace pins and keys</td></tr>
<tr><td></td><td>Low oil volume</td><td>Check flow divider and pump drive belts</td></tr>
<tr><td></td><td>Pitman arm ball worn "egg-shaped"</td><td>Replace pitman arm assembly where riveted ball is used or only where bolted ball is used (vertical socket)</td></tr>
<tr><td></td><td>Improperly adjusted drag link, pitman arm to drag link and steering arm to drag link</td><td>Adjust drag link, drag link to pitman arm and drag link to steering arm</td></tr>
<tr><td></td><td>Loose bracket frame to bracket or bracket to gear</td><td>Remove bracket, clean frame and bracket check radius of frame making sure bracket is not bearing on radius surface
Check bracket for wear from working
Replace bracket and tighten to recommended torque rating according to size and grade of bolts
If necessary, replace bracket with new one</td></tr>
<tr><td></td><td>Rack on piston damaged</td><td>Replace parts as required</td></tr>
<tr><td></td><td>Damaged pinion gear on output shaft</td><td>Replace pinion gear</td></tr>
<tr><td></td><td>Damaged output shaft splines</td><td>Replace output shaft</td></tr>
<tr><td></td><td>Worn output shaft bushings</td><td>Replace bushings and polish shaft to remove bronze deposits</td></tr>
<tr><td></td><td>Worn pitman arm splines</td><td>Replace worn parts</td></tr>
<tr><td></td><td>Worn actuating shaft and valve threads</td><td>Replace worn parts as required
Locate cause of wear and repair as required</td></tr>
<tr><td></td><td>Free play in miter gears of angle drive</td><td>Remove miter gear housing shims to mesh gears</td></tr>
<tr><td></td><td>Damaged reversing springs</td><td>Check and repair as required</td></tr>
<tr><td></td><td>Universal joint yoke loose on actuating shaft</td><td>Repair or replace damaged parts, check for spline wear</td></tr>
</table>

Steering Troubleshooting Guide (Cont.)

Symptom	Possible cause	Remedy
No attempt to return straight ahead from turns	No positive caster	Set to 4° to 6° positive caster
	Steering column bind	Check and repair U-joints and support bearings
	Steering gear mounting distorted	Shim mounting pads to correct piston to bore interference
	Linkage ball sockets seized or binding	Check and repair or replace
	King pins seized or binding	Repair or replace
	Knuckle clearance misadjust	Adjust clearance to specifications
	Oil flow rate incorrect	Check and correct supply pump or controls

Note:

Acme thread wear generally comes from inadequate lubrication or excessive manual steering of the vehicle. Manual steering results from inadequate pump pressure or flow or an overloaded front axle where you need steering forces in excess of the hydraulic design of the steering gear.

Note: Freeplay

The movement of the shuttle type actuating valve within the piston, along with the normal clearances required between operating parts in the steering gear will produce a certain amount of unresponsive motion at the rim of the steering wheel. This unresponsive motion is inherent to the design and must be considered normal. With recent advances in technology and manufacturing methods it has been possible to considerably reduce the amount of this unresponsive motion. Steering gears in service prior to July 1978 could be expected to have 3¾ to 4 inches unresponsive motion. Current production steering gears in service will have 1¾ to 2¼ inches of unresponsive motion. Various combinations of steering gear ratios and steering wheel diameters could effectively reduce these maximum allowances.

Unresponsive motion is measured at the rim of the steering wheel. It must, therefore, be noted that any freeplay in the steering column and related components will affect your measurement. The steering gear mounting must be tight and steering linkage wear adjusted out or worn parts replaced.

The vehicle should be standing on a smooth shop floor with the engine idling when unresponsive motion is checked. Measurement is made at the rim of the steering wheel, from initial tire and wheel movement left steer, to initial tire and wheel movement right steer.

Information provided courtesy of R.H. Sheppard Co., Inc.

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PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________________
Address ____________________
Phone # ____________________

Date In __________
Date Out __________

JOB TICKET

Customer Name ____________________
Customer Address ____________________
Customer Phone # ____________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________________

Services/repairs made: ____________________

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________________ Date __________

Technician __________
Supervisor __________

Unit Contents

Student Components

Student Page

Objective Sheet 1C-3

Information Sheet 1C-5

Job Sheets

1—Inspect Front Suspension Components 1C-15
2—Remove and Replace Front Spring Suspension Components . . 1C-19

Objective Sheet

Unit Objective

After completing this unit, the student should be able to inspect and replace front suspension components. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to front suspension with their definitions.
2. State purposes of front suspension.
3. Identify front suspension components.
4. Match front suspension components with their correct functions and characteristics.
5. Distinguish between basic designs of springs.
6. Identify types of front spring assembly ends.
7. Complete statements concerning dimensions and load ratings of spring assemblies.
8. Identify types of spring eyes.
9. Identify shapes of u-bolts.
10. Label dimensions of u-bolts.
11. Complete statements concerning the identification and measurement of shock absorbers.
12. Inspect front suspension components. (Job Sheet 1)
13. Remove and replace front spring suspension components. (Job Sheet 2)

Information Sheet

Objective 1

Terms and definitions

a. **Axle rating**—Amount of weight the axle is approved to carry

Note: This capacity is measured at the ground and is abbreviated GAWR (Gross Axle Weight Rating).

b. **Axle seat**—Flat machined area of axle where the spring rests; contains two holes for each u-bolt and one blind hole for the center bolt head

c. **Constant rate spring**—Leaf spring that deflects at a constant rate as load is added

Example: If 3,000 lbs. deflects the spring one inch, 6,000 lbs. would deflect the same spring two inches. This is constant rate.

d. **Jounce**—Upward flexing (compression) of the spring as it absorbs energy while a wheel is going over a bump

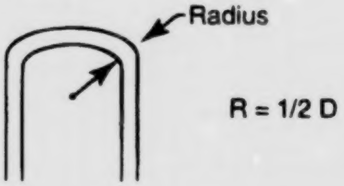
e. **Leaf**—One thin sheet or plate of an object

f. **Leaf spring**—Special type of elastic or resilient device (spring) made up of stacked strips or leaves

g. **Radius** (pl - radii)—Distance from the center to the edge of a circle; one half of the diameter

Note: This dimension is critical when measuring u-bolts.

Figure 1



h. **Rebound**—Downward flexing of the spring as it releases energy while the wheel returns to its normal position

i. **Spring rate**—Amount of load that will deflect the spring one inch

j. **Sprung weight**—Weight of the vehicle that is supported by the springs

k. **Unsprung weight**—Weight that is not supported by the springs; includes the axle, tires, rims, brakes, and some of the steering components

Information Sheet

Objective 2

Purpose of front suspension

a. To support the weight of the vehicle

b. To cushion the frame and cab of the vehicle from road shocks

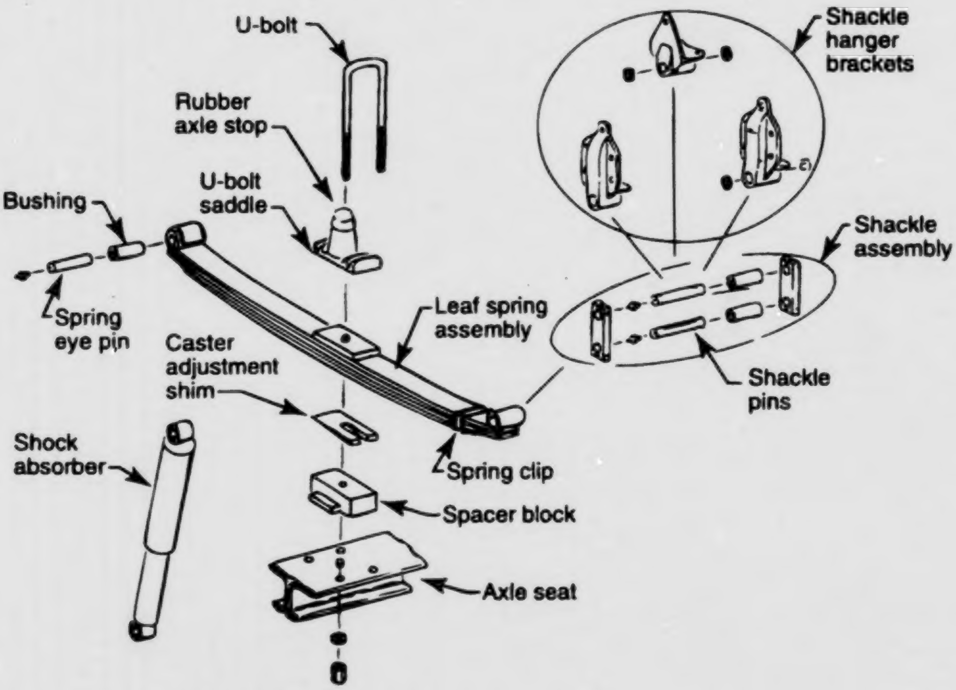
c. To transfer braking forces to the frame

d. To maintain axle alignment

Objective 3

Front suspension components

Figure 2


U-bolt
Rubber axle stop
U-bolt saddle
Bushing
Spring eye pin
Caster adjustment shim
Leaf spring assembly
Shock absorber
Spring clip
Spacer block
Axle seat
Shackle hanger brackets
Shackle assembly
Shackle pins

Courtesy of Dayton Parts Inc.

Objective 4

Functions and characteristics of front suspension components

a. **Front hanger bracket**

- Attaches the front of the leaf spring assembly to the frame
- Bolted or riveted to the frame
- Locates the spring assemblies so that the front axle will be exactly perpendicular to the frame rails

b. **Spring eye pin**

- Made of hardened steel
- Passes through holes in the front hanger bracket and the spring eye, allowing the spring assembly to pivot inside the bracket
- May be smooth stock or threaded and usually contains a drilled passage for lubricant
- Is fastened rigidly in the front hanger bracket by pinch bolts

c. **Bushings**

- Provide a bearing surface between the eye of the spring and the pin
- Usually contain some type of grease reservoir; internal grooves are filled with grease from the spring pin
- Are used in each end of the spring and in the rear hanger (three on each assembly).
- May be several types—smooth bore, threaded, or integral rubber

d. **Leaf spring assembly**

- Absorbs, stores, and then releases energy as the vehicle passes over bumps
- Made up of individual leaves held together with a round center bolt, which keeps the leaves in alignment before the spring assembly is installed in the vehicle and serves as a locating dowel for the front axle

  Note: After the assembly is in place, the tension of the u-bolts maintains the spring assembly alignment.

e. **Spring clips**—Used to prevent individual leaves from spreading sideways

f. **U-bolts**

- Hold the spring assembly to the axle seat
- Maintain the leaves in alignment when properly torqued

g. **U-bolt saddle** (sometimes called a top plate)

- Contains a groove for each u-bolt
- Locates the tops of the u-bolts and distributes their clamping force over a larger area

h. **Rubber axle stop**

- Used to prevent excessive flexing of the spring if the front wheels should encounter a large bump
- May be integral with the u-bolt saddle or may be bolted to the frame

Note: Rubber tips are used to prevent harsh metal-to-metal contact.

i. **Spacer block** (or pad)

- May be used to achieve the desired frame height with a particular spring arch/wheel size combination
- Contains a dowel which will fit into the axle seat; has a hole directly above the dowel to receive the head of the center bolt

Note: Spacer blocks are not used on all front suspensions.

j. **Caster adjustment shims**

- Installed on top of the axle seat
- Used to adjust the axle caster (rearward tilt of the kingpins)
- Available in a number of widths and wedge angles

Examples: 2½″, 3″, 3½″, 4″ wide and ½°, 1°, 1½°, 2°, 2½°, 3°, 3½°, 4° angles

k. **Shackle assembly**

Note: Side links may be constructed as a one-piece shackle assembly or two separate links.

- Forms the connection between the rear of the spring and the rear hanger bracket
- Allows the spring length to change as the spring flexes

l. **Shackle pins**

- Pass through the rear spring eye and the shackle side links forming a flexible joint
- Are very similar in construction to front eye pins

m. **Shackle hanger brackets**

- Are bolted or riveted securely to the frame
- Make the last part of the joint between the rear of the spring and the frame

n. **Shock absorbers**

- Prevent the spring from over flexing during rebound and thus dampen the spring oscillations which would otherwise occur
- Do **not** actually absorb road shocks. The spring absorbs the energy during jounce.

o. **Shock absorber brackets**

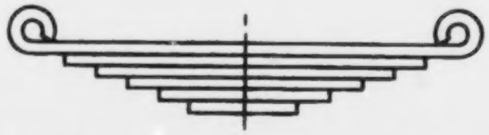
- Form the joint between the shock absorber and the frame at the top and between the shock and the axle at the bottom
- The upper mount is bolted or riveted to the frame.
- The lower mount is usually fastened to the axle by the u-bolts.

Objective 5

Basic designs of springs

a. **Stepped spring**—Spring assembly consisting of a stack of spring leaves with the shortest leaf placed on the bottom and each successive leaf longer which helps to distribute the stress evenly

Figure 3

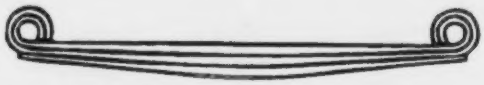


Courtesy of Peterbilt Motors Company/PACCAR Inc.

b. **Tapered leaf spring**—Spring assembly consisting of a stack of full-length leaves in which each leaf is tapered in thickness to distribute the stress evenly

Note: The individual leaves are separated with a Delrin liner to cause a gap between the leaves. The gap allows each spring to act as a separate spring. Tapered leaf springs can carry more weight than a stepped spring of equal weight.

Figure 4



Courtesy of Peterbilt Motors Company/PACCAR Inc.

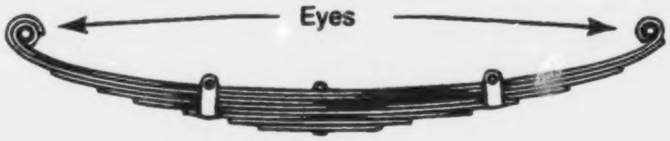
Objective 6

Types of front spring assembly ends

Note: Spring assemblies are constructed of individual leaves which may be flat or tapered design. Front springs are identified according to the ends of the springs as follows:

a. **Eyes on both ends**

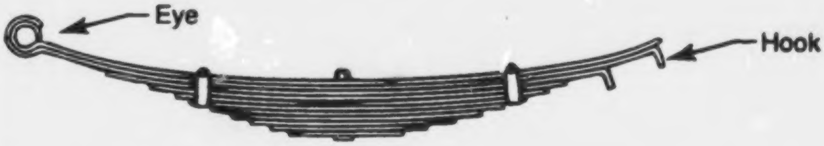
Figure 5



Courtesy of Dayton Parts Inc.

b. **Eye and hook**

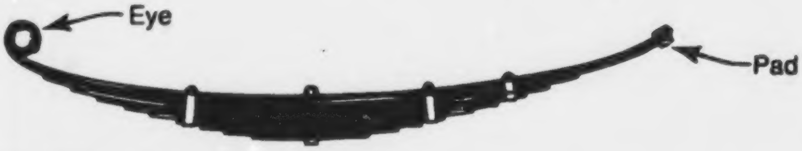
Figure 6



Courtesy of Dayton Parts Inc.

c. **Eye and pad**

Figure 7



Courtesy of Dayton Parts Inc.

Objective 7

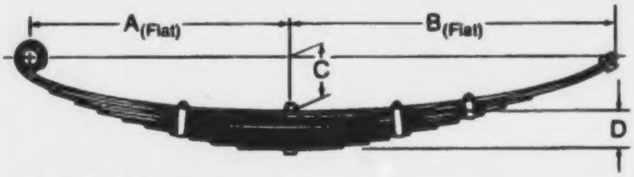
Dimensions and load ratings of spring assemblies

Note: Dimensions and load ratings are required when replacing spring assemblies.

a. Dimensions

- Width
- Length of long-end (eye to center bolt)
- Length of short-end (center bolt to eye, hook, or pad)
- Number of leaves
- Pad thickness
- Arch

Figure 8



A = Short end
B = Long end
C = Arch
D = Pad thickness

Courtesy of Dayton Parts Inc.

b. Load rating

- This is a function of length, width, number of leaves, and type of steel and is calculated by the manufacturer.
- This is often stenciled on new springs.

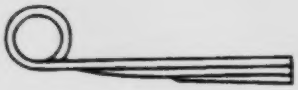
Information Sheet

Objective 8

Types of spring eyes

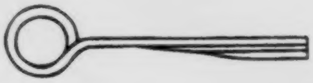
a. Up turned eye

Figure 9



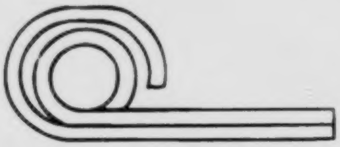
b. Berlin eye

Figure 10



c. Military wrap

Figure 11

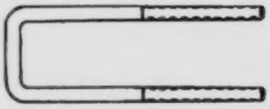


Objective 9

Shapes of U-bolts

a. Square bend

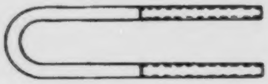
Figure 12



Courtesy of BATCO

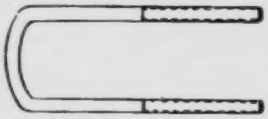
b. Round bend

Figure 13



c. Semi-round bend

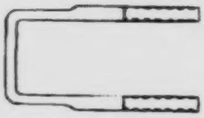
Figure 14



Courtesy of BATCO

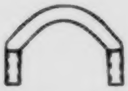
d. Flattened square bend

Figure 15



e. Special shape

Figure 16



Courtesy of BATCO

Objective 10

Dimensions of U-bolts

Note: Suspension u-bolts are a critical part of the front suspension. They are grade 8 quality and should never be replaced with ordinary hardware. Both the correct shape and dimensions should be measured for correct replacement.

a. Thread diameter and pitch

b. U-bolt length

c. Width

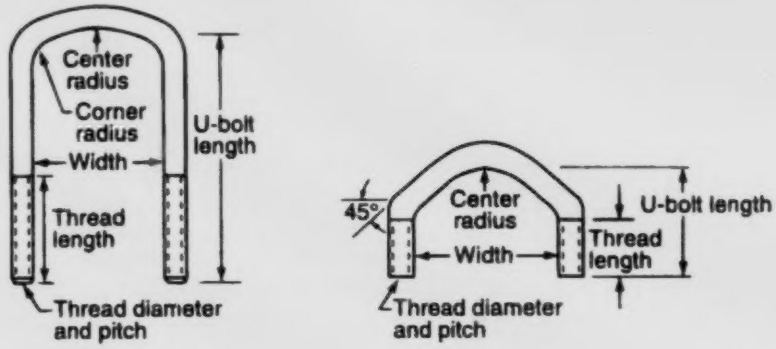
d. Thread length

e. Center radius

f. Corner radius

Note: It is critical that both radii (center and corner) of u-bolts match the u-bolt saddle. Check for correct fit.

Figure 17


Center radius
Corner radius
U-bolt length
Width
Thread length
Thread diameter and pitch
45°
Center radius
U-bolt length
Thread length
Width
Thread diameter and pitch

Courtesy of BATCO

Objective 11

Identification and measurement of shock absorbers

a. Shock absorbers may be identified by the number stamped on the shock absorber tube or dust cover.

b. If the number is not readable, identify the shock as follows:

- Collapsed length (slowly push shock until it is collapsed)
- Extended length (slowly pull shock until it is completely extended)
- Rubber bushing inside diameter

Objective 12

Job Sheet 1—Inspect Front Suspension Components

Name ______________________ Attempt Number ______

Date ______________________ Overall Rating ______

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Parts are inspected accurately	______
• Specifications are accurate	______
• Findings are recorded on job ticket	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Torque wrench, ¾" drive
- Anti-seize compound
- Pry bar
- Floor jack
- Jack stands
- Front suspension to be worked on
- Others—as recommended by instructor and equipment service manual

Guidelines

- U-bolts must be tightened regularly to keep the spring leaves clamped tightly together. U-bolts stretch and new spring assemblies "settle-in" after a short time, relieving the u-bolt tension.

- Loose u-bolts are a major cause of spring breakage. Loose u-bolts also allow the leaves to shift and even shear the spring assembly center bolt, resulting in axle misalignment. The importance of keeping the u-bolts tight cannot be over-emphasized.

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Chock the rear wheels, set parking brake, and remove ignition key.

☐ 4. Inspect u-bolts for corrosion, missing nuts or washers, and correct location in the spring saddle. Torque the nuts to the manufacturer's specifications.

Important: U-bolts should be torqued with the weight of the vehicle resting on the springs.

☐ 5. Record your findings about the u-bolts on the job ticket. Include the following information:

a. U-bolt condition (O.K., broken, corroded)

b. Does u-bolt fit top plate correctly?

c. U-bolt diameter and thread pitch

d. Torque specifications

☐ 6. Visually inspect the front spring assemblies. Look for cracks, nicks, missing spring clips, and any evidence of spring scrubbing. Sagging (worn out) springs may cause leaning of the vehicle to right or left, insufficient clearance between the axle stop and the frame, and/or rear shackles to operate at 45 degrees or more from vertical.

☐ 7. Record your findings about the front spring assemblies on the job ticket. Include the following information:

a. Spring clips (O.K., missing, damaged)

b. Spring assemblies (O.K., cracked, broken, sagging)

☐ 8. Visually inspect shock absorbers. Look for oil leaks, damaged rubber bushings, and broken mounts. If the vehicle has just been driven (50 miles or more), the shock absorber should be warm to the touch. A cold shock absorber is not working properly.

☐ 9. Test shocks by disconnecting at the lower mount, then slowly moving the lower end of shock to the fully compressed and fully extended positions. You should feel a steady, smooth resistance through the full stroke.

☐ 10. Record your findings about the shock absorbers on the job ticket. Include the following information:

a. Shock absorbers (O.K., leaking, no resistance, rough operation)

b. Rubber mounts (O.K., damaged, missing)

☐ 11. Inspect the spring and shackle bushings by using a pry bar between the spring and the bracket or shackle. (It may be helpful to remove most but not all of the vehicle's weight from the suspension by supporting the frame with jack stands high enough to lift the front wheels from the floor. Then load the suspension by jacking under the axle.) There should be very little clearance between pins and bushings. If you feel or see movement, they're worn out and will need to be replaced.

☐ 12. Record your findings about the spring and shackle bushings on the job ticket. Include the following information:

a. Pins and bushings (O.K., excessive clearance)

☐ 13. Obtain instructor's and customer's approval for replacements to be made. Have them sign job ticket.

☐ 14. Make replacements on required components as approved. Record on job ticket.

a. Replace damaged u-bolts with new grade 8 u-bolts, hardened washers, and deep nuts. Use anti-seize compound to coat the threads.

b. Spring assemblies and shock absorbers should always be replaced in pairs.

☐ 15. Turn in job ticket when finished.

☐ 16. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ______

Address ______

Phone # ______

Date In ______

Date Out ______

JOB TICKET

Customer Name ______

Customer Address ______

Customer Phone # ______

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ______

Services/repairs made: ______

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

______ Date ______

Technician ______

Supervisor ______

Objective 13

Job Sheet 2—Remove and Replace Front Spring Suspension Components

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Caster shim position noted	______
• Spring measurements accurate	______
• Bushings properly installed	______
• Torque specs are accurate	______
• Findings are recorded on job ticket	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Air wrench and sockets, 3/4˝ drive
- Bushing driver set
- Torque wrenches, 1/2˝ and 3/4˝
- Cutting torch
- Floor jack
- Jack stands
- Front suspension to be worked on
- Others—as recommended by instructor and equipment service manual

Guidelines

- It is recommended to replace shock absorbers and spring assemblies in pairs. If one side is worn or defective, the other side will fail in a short time.
- Although you are going to work on both spring assemblies, do not remove both springs at the same time because the front axle will be very difficult to hold in place.

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Chock the rear wheels, set parking brake, and remove ignition key.

☐ 4. Jack up the front of the vehicle and support the **frame** (not the axle) with jack stands. The frame should be high enough to lift the front wheels 1 to 2 inches from the floor.

☐ 5. Support the front axle with a floor jack.

STOP! Get instructor approval before continuing.

Vehicle and front axle are safely supported: ________ (instructor initials)

☐ 6. Disconnect shock absorber from lower mount.

☐ 7. Remove u-bolts from spring assembly.

Note: If u-bolts are extremely rusted, they will be very difficult to remove. Since they must be replaced, it may be faster and in the long run cheaper for the customer to cut the u-bolt with a cutting torch.

☐ 8. Remove the pinch bolts and drive the pins out of the rear shackle assembly.

☐ 9. Remove the front spring eye pins. Remember, these pins may be threaded type, requiring you to screw them out of the spring bushing. Refer to manufacturer's service manual.

☐ 10. Note the position of the caster shim and record on the job ticket. (Thick edge to front or rear?)

Note: The thick edge is usually to the rear.

☐ 11. Lower the front axle and remove the spring assembly from the vehicle.

☐ 12. Record the following information on the job ticket:

  ☐ a. Vehicle make

  ☐ b. Vehicle year and model

  ☐ c. Front axle capacity. (Axle weight ratings may be found on the VIN label usually located inside the driver's door frame.)

  ☐ d. Spring width

- ☐ e. Number of leaves
- ☐ f. Pad thickness
- ☐ g. Length (long end and short end)
- ☐ h. Type of eye (up turned, Berlin, military wrap)

  Note: Refer to manufacturer's parts book and/or spring manufacturer's catalog to make sure you obtain the correct parts.

☐ 13. Replace spring assembly with proper approval.

- ☐ a. Clean the axle seat and locating dowel hole.
- ☐ b. Remove and install bushings with a suitable bushing driver.

  Note: Some spring bushings must be welded in place. Refer to service manual for detailed instructions.

- ☐ c. Install new pins and secure with pinch bolts. Now is a good time to lubricate the pins. Since there is no weight on them, grease will flow around the entire surface of the pin.

☐ 14. Position the caster shim and spacers in their original position.

☐ 15. Raise the front axle and install the top plate and u-bolts.

☐ 16. Remove the jack stands and lower the vehicle to the floor.

☐ 17. Torque the pinch bolts, u-bolts, and shock bolt to specs. Record the recommended torques on the job ticket.

- ☐ a. U-bolts (diameter and torque)
- ☐ b. Pinch-bolts (diameter and torque)
- ☐ c. Shock mounts (diameter and torque)

☐ 18. Turn in job ticket when finished.

☐ 19. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____________________

____

____

JOB TICKET

School/Work Name ____________

Address ____________

Phone # ____________

Date In ____________

Date Out ____________

Customer Name ____________

Customer Address ____________

Customer Phone # ____________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________

Services/repairs made: ____________

LABOR

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________ Date ____________

Technician ____________

Supervisor ____________

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE
	TOTAL PARTS/MATERIALS	

SPECIFICATIONS CHECKED

Unit Contents

Student Components

Student Page

Objective Sheet 2C–3

Information Sheet 2C–5

Job Sheets

1—Inspect Rear Spring Suspension Components 2C–15
2—Replace Rear Spring Suspension Components 2C–19

Objective Sheet

Unit Objective

After completing this unit, the student should be able to inspect and replace rear spring suspension components. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to rear spring suspension with their definitions.
2. State purposes of rear suspension.
3. Distinguish among types of springs.
4. Identify rear spring suspension components.
5. Match rear spring suspension components with their correct functions.
6. Identify types of rear spring assembly ends.
7. List dimensions required for ordering spring assemblies.
8. Select true statements concerning load rating of spring assemblies.
9. Complete statements concerning failure of spring assemblies.
10. Inspect rear spring suspension components. (Job Sheet 1)
11. Replace rear spring suspension components. (Job Sheet 2)

Information Sheet

Objective 1

Terms and definitions

a. **Axle alignment**—Adjustments made in the relationship between the axles, steering and suspension components, and tires to bring them into correct positions

b. **Axle spacing**—Center-to-center (CC) distance between the rear axles on a tandem suspension

c. **Drive line angularity**—Angles between drive/suspension components and the frame

d. **Equalizer**—Device that distributes a force or weight evenly or uniformly

e. **Load rating**—Grade classification of a material according to how much force or weight it can carry

f. **Slipper**—Device used on the ends of leaf springs which allows the spring to slide freely in the hanger

g. **Spring rate**—Amount of load that will deflect the spring one inch

h. **Sprung weight**—Weight of the vehicle that is supported by the springs

i. **Torque rod**—Separate suspension component that transfers braking and driving forces to the frame and maintains drive line angularity

j. **Torque leaf**—Part of some spring assemblies that acts as a torque rod

k. **Unsprung weight**—Weight that is not supported by the springs; includes the axle, tires, rims, brakes, and some of the steering components

Objective 2

Purposes of rear suspension

a. To support the weight of the vehicle and its load

b. To cushion the frame and cab of the vehicle from road shocks

c. To transfer braking forces and driving forces from the axle to the frame

d. To maintain axle alignment

e. To maintain drive line angularity

Objective 3

Types of springs

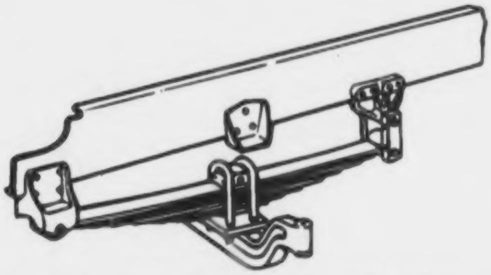
a. **Constant rate spring**

- Spring deflects at a constant rate as load is added.

  Example: If 3,000 lbs. deflects the spring one inch, then 6,000 lbs. would deflect the same constant rate spring two inches.

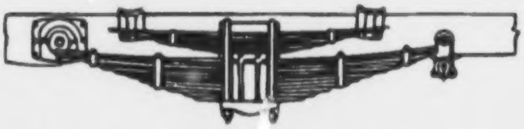
- May be used in both front and rear axle applications

  Figure 1—Front axle application (constant rate)



Courtesy of Navistar International Transportation Corp.

Figure 2—Rear axle application (constant rate)



Courtesy of Navistar International Transportation Corp.

b. **Vari-rate (progressive rate) spring**

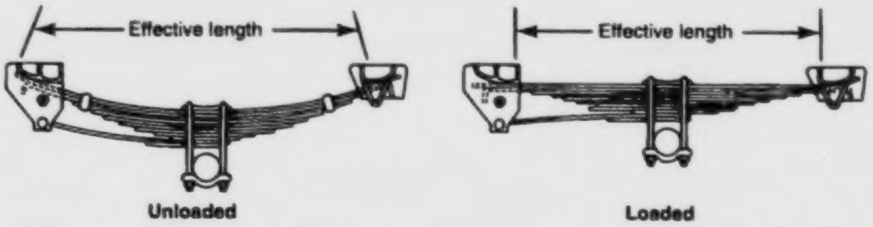
- Spring deflects at a slower rate as load is added.

  Example: If 3,000 lbs. deflects the spring one inch, then as the rate increases, 6,000 lbs. would deflect the same spring 1½ inches.

- Provides a soft, easy riding spring rate when the vehicle is empty, while also providing enough spring rate when fully loaded to function without sagging

- Several schemes are used to cause springs to vary the rate as load is applied. If the spring mounts are cam shaped, the effective length of the spring will change as load is applied.

Figure 3—Vari-rate spring

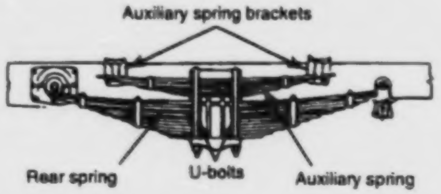

Effective length
Effective length
Unloaded
Loaded

Courtesy of Navistar International Transportation Corp.

c. **Auxiliary spring**

- Used to increase spring rate when vehicle is loaded
- Does not contact the mount until the vehicle is partially loaded and the main spring is partially deflected
- Usually mounted on top of the main spring assembly
- Sometimes known as helper or overload spring

Figure 4—Auxiliary spring

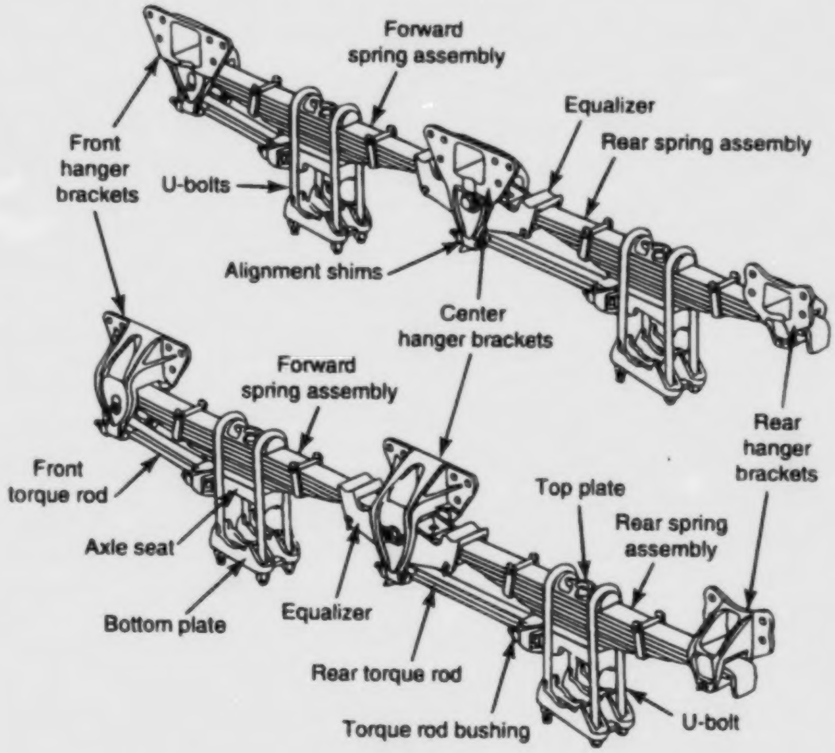

Auxiliary spring brackets
Rear spring
U-bolts
Auxiliary spring

Courtesy of Navistar International Transportation Corp.

Objective 4

Rear spring suspension components

Figure 5


Forward spring assembly
Equalizer
Rear spring assembly
Front hanger brackets
U-bolts
Alignment shims
Center hanger brackets
Forward spring assembly
Rear hanger brackets
Front torque rod
Top plate
Rear spring assembly
Axle seat
Bottom plate
Equalizer
Rear torque rod
Torque rod bushing
U-bolt

Courtesy of Hendrickson Truck Suspension Systems

Objective 5

Functions of rear spring suspension components

a. **Front hanger bracket**

- Attaches the front of the forward spring assembly to the frame
- Anchors the front torque rod (or torque leaf) to the frame
- May have a cam-shaped spring contact surface to provide progressive spring rate

b. **Center hanger bracket**

- Attaches the rear of the forward spring and the front of the rear spring to the frame
- Provides a pivot point for the equalizer
- Anchors the rear torque rod (or torque leaf) to the frame

c. **Rear hanger bracket**

- Attaches the rear of the rear spring to the frame
- May have a cam-shaped spring contact surface to provide progressive spring rate

d. **Spring assembly**

- Absorbs, stores, and then releases energy as the vehicle passes over bumps
- The individual leaves which make up the assembly are held together with a center bolt to keep the leaves in alignment before the spring assembly is installed in the vehicle.
- After the assembly is in place, the tension of the U-bolts maintains the spring assembly alignment.
- The head of the center bolt is round (rather than hex) and serves as a locating dowel for the rear axle.
- The spring seat has a hole to receive the head of the center bolt.

e. **Equalizer**

- Oscillates inside the center hanger bracket
- "Equalizes" the weight supported by each axle of a tandem assembly, even as the vehicle passes over bumps.
  - As the forward rear axle begins to go over a bump, the equalizer will tip up at the forward end (and down at the rear). This allows the forward axle to "step" up and over the bump.
  - At the same time, the rear axle is pushed down and continues to support its share of the load. As the vehicle continues over the bump, the equalizer will tip up at the rear as the rear axle "steps" over the bump.

f. **Equalizer bushing or bearing**

- Reduces friction and prevents wear between the equalizer and the pivot shaft
- Usually constructed of rubber or urethane bonded to a steel bushing

g. **Torque rod**

- Used with slipper type springs to transfer braking and driving forces from the axle to the frame
- Will have some means of adjustment to provide a means of adjusting the axle alignment
- Used in pairs, two torque rods per axle
- May be adjustable or rigid type

h. **Torque leaf (radius leaf)**

- Used in spring suspensions in place of torque rods
- Part of the spring assembly but does little to support weight
- Locates the alignment of the axle and transfers braking and driving forces to the frame
- Attaches to the frame with eccentric bushings, which allow for adjustment of the axle alignment

i. **Torque rod bushing**

- Reduces friction and prevents wear between torque rod and hanger brackets and between torque rod and axle seat
- Constructed of urethane or rubber bonded to a steel bushing
- May be straddle mounted (adjust with shims) or solid concentric

j. **Alignment shim(s)**

- Installed between torque rod and hanger brackets or between torque rod and axle seat
- Changes the effective length of the torque rod to provide a means to align the rear axle to the frame

k. **U-bolts**

- Hold the spring assembly to the axle seat
- Maintain leaves in alignment when properly torqued

l. **Top plate** (sometimes known as u-bolt saddle)

- Contains a groove for each u-bolt
- Locates the tops of the u-bolts and distributes their clamping force over a larger area

m. **Axle seat**

- Located between the axle and the bottom of the spring assembly
- The angle of the axle seat will determine the pinion angle of the rear axle.
- Also provides a place to anchor the torque rod to the axle
- A hole drilled in the axle seat receives the head of the spring center bolt and thus locates the spring assembly in correct position on the axle.

n. **Bottom plate**

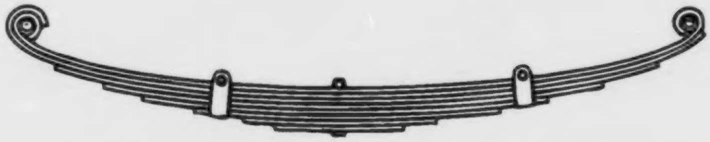
- Located underneath the axle
- Provides a clamping surface for the u-bolt nuts
- The u-bolt holes in the bottom plate will be drilled at the same angle as the axle seat pinion angle.

Objective 6

Types of rear spring assembly ends

a. **Eyes on both ends**—Used on single axle suspensions

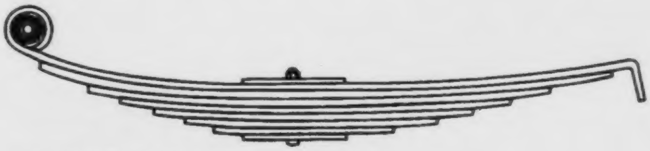
Figure 6



Courtesy of Dayton Parts Inc.

b. **Eye and slipper**—Used on single axle and tandem axles

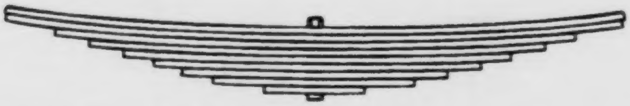
Figure 7



Courtesy of Dayton Parts Inc.

c. **Slipper type**—Ends slide (slip) back and forth; must use torque rods to maintain axle alignment

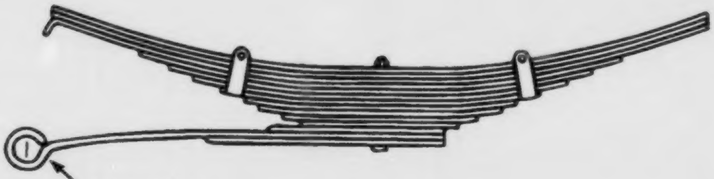
Figure 8



Courtesy of Dayton Parts Inc.

d. **Slipper with torque leaf**—Used on single and tandem suspensions

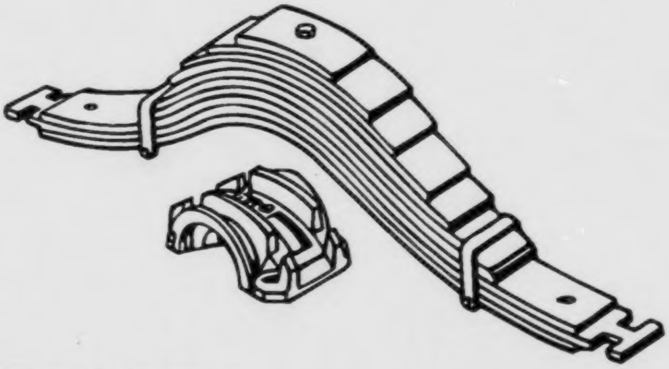
Figure 9



Courtesy of Dayton Parts Inc.

e. **Camelback**—Used on Mack vehicle tandem suspensions; use two springs instead of four; the spring itself acts as the equalizer

Figure 10



Courtesy of Dayton Parts Inc.

Objective 7

Dimensions required for ordering spring assemblies

a. Axle spacing—Common spacing dimensions are 50″ and 52″ CC

b. Spring width—Common dimensions are 3″, 3½″, and 4″

c. Number of leaves

d. Length of long end (rear of spring to center bolt)

e. Length of short end (front of spring to center bolt)

f. Thickness of pad

g. Arch

Objective 8

Load rating of spring assemblies

a. This is a function of length, width, number of leaves, and type of steel.

b. Load rating is often stenciled on new springs.

c. May be rated by the manufacturer at the axle (unsprung weight) or at the ground (sprung plus unsprung)

d. Common capacities range from 5,000 to 20,000 lbs.

Note: The letter "M" is often used to abbreviate thousand, so a spring labeled 8M has an 8,000 lb. capacity.

Objective 9

Failure of spring assemblies

a. All springs will eventually fail from fatigue due to repeated flexing.

b. Factors that affect spring life include:

- **Load factor**—The greater the load, the shorter the life of the spring.
- **Maintenance**—U-bolts must be retorqued after initial installation and at specified service intervals in order for springs to last as long as possible.
- **Corrosion**—Proper paints and care will slow the spread of corrosion.
- **Shock absorbers**—Since shock absorbers slow the rate of jounce and rebound, the spring is deflected less every time the vehicle hits a bump. Therefore, they will last longer.

Objective 10

Job Sheet 1—Inspect Rear Spring Suspension Components

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Parts are inspected accurately	______
• Specifications are accurate	______
• Findings are recorded on job ticket	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Torque wrench, ¾" drive
- Anti-seize compound
- Pry bar
- Floor jack
- Jack stands
- Rear suspension to be worked on
- Others—as recommended by instructor and equipment service manual

Guidelines

- U-bolts must be tightened regularly to keep the spring leaves clamped tightly together. U-bolts stretch and new spring assemblies "settle-in" after a short time, relieving the U-bolt tension.

- Loose u-bolts are a major cause of spring breakage. Loose u-bolts also allow the leaves to shift and even shear the spring assembly center bolt, resulting in axle misalignment. The importance of keeping the u-bolts tight cannot be over-emphasized.

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Chock the front wheels, release the park brakes (must have at least 100 psi in air brake reservoirs), and remove ignition key.

☐ 4. Inspect U-bolts for corrosion, missing nuts or washers, and correct location in the spring saddle. Torque the nuts to the manufacturer's specifications.

Important: U-bolts should be torqued with the weight of the vehicle resting on the springs.

☐ 5. Record your findings about the u-bolts on the job ticket. Include the following information:

a. U-bolt condition (O.K., broken, corroded)

b. Does u-bolt fit top plate correctly?

c. U-bolt diameter and thread pitch

d. Torque specifications

☐ 6. Visually inspect the rear spring assemblies. Look for broken leaves, cracks, nicks, corrosion, and missing spring clips. Sagging (worn out) springs may cause the vehicle to lean to right or left.

☐ 7. Record your findings about the rear spring assembly on the job ticket. Include the following information:

a. Spring assemblies (O.K., cracked, broken, corroded, sagging)

b. Spring clips (O.K., missing, damaged)

☐ 8. Visually inspect shock absorbers. Look for oil leaks, damaged rubber bushings, and broken mounts. If the vehicle has just been driven (50 miles or more), the shock absorber should be warm to the touch. A cold shock absorber is not working properly.

☐ 9. Test shocks by disconnecting at the lower mount, then slowly moving the lower end of shock to the fully compressed and fully extended positions. You should feel a steady, smooth resistance through the full stroke.

☐ 10. Record your findings about the shock absorbers on the job ticket. Include the following information:

a. Shock absorbers (O.K., leaking, resistance, rough operation)

b. Rubber mounts (O.K., damaged, missing)

☐ 11. Inspect the torque arms or torque leaves and bushings. Remember, torque arms have bushings on both ends. Worn bushings can be detected by prying on the torque arm or leaf; there should be very little looseness.

☐ 12. Record your findings on the job ticket. Include the following information:

a. Torque arms (O.K., missing, damaged)

b. Torque leaves (O.K., broken, center bolt sheared)

c. Bushings (O.K., worn out, missing or loose bolts)

☐ 13. Inspect the spring mounts. Jack up the rear of the vehicle and support the frame with jack stands. Visually inspect the front and rear hanger spring cam surfaces. Use a pry bar to check the equalizer bushing; it should have very little looseness. Check the frame mounting bolts.

☐ 14. Record your findings on the job ticket. Include the following information:

a. Front hanger (O.K., broken, damaged, loose or missing bolts)

b. Center hanger (O.K., broken, damaged, loose or missing bolts)

c. Equalizer (O.K., broken, damaged, bushing worn out)

d. Rear hanger (O.K., broken, damaged, loose or missing bolts)

☐ 15. Obtain instructor's and customer's approval for replacements to be made. Have them sign job ticket.

☐ 16. Make replacements on required components as approved. Record on job ticket.

a. Replace damaged u-bolts with new grade 8 U-bolts, hardened washers, and deep nuts. Use anti-seize compound to coat the threads.

b. Spring assemblies and shock absorbers should always be replaced in pairs.

☐ 17. Turn in job ticket when finished.

☐ 18. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
	TOTAL PARTS/MATERIALS		

SPECIFICATIONS CHECKED

School/Work Name ______________________

Address ______________________

Phone # ______________________

Date In ____________

Date Out ____________

JOB TICKET

Customer Name ______________________

Customer Address ______________________

Customer Phone # ______________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ______________________

Services/repairs made:	LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

______________________ Date ____________

Technician ____________

Supervisor ____________

Objective 11

Job Sheet 2—Replace Rear Spring Suspension Components

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Spring measurements are accurate	______
• Components are cleaned at mating surfaces	______
• Torque specifications are accurate	______
• Findings are recorded on job ticket	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Air wrench and sockets, ¾" drive
- Torque wrenches, ½" and ¾" drive
- Cutting torch
- Floor jack
- Jack stands
- Rear spring suspension to be worked on
- Others—as recommended by instructor and equipment service manual

Guidelines

- It is recommended to replace shock absorbers and spring assemblies in pairs. If one side is worn or defective, the other side will fail in a short time.
- Although you are going to work on both spring assemblies, do not remove both springs from one axle at the same time because the axle will be very difficult to hold in place.

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Chock the rear wheels, release the parking brake, and remove ignition key.

☐ 4. Jack up the rear of the vehicle and support the **frame** (not the axle) with jack stands. The frame should be high enough to lift the wheels 2 to 3 inches.

☐ 5. Support the axle with a floor jack.

STOP! Get instructor approval before continuing.

Vehicle frame is safely supported: _____________ (instructor initials)

☐ 6. Remove the wheels if needed to gain better access to the spring assembly.

☐ 7. Disconnect shock absorbers (if present).

☐ 8. Remove the u-bolts from the spring assembly.

Note: If the u-bolts are extremely rusted, they will be very difficult to remove. Since they must be replaced, it may be faster and in the long run cheaper for the customer to cut the u-bolts with a cutting torch.

☐ 9. Remove the retainer bolts (if present) from the equalizer and front or rear hanger.

☐ 10. Lower the axle with the floor jack and remove the spring assembly from the vehicle.

☐ 11. Identify the following information about the spring and record on the job ticket:

a. Vehicle make

b. Vehicle year and model

c. Rear axle capacity (check VIN label usually located inside the driver's door frame)

d. Spring width

e. Number of leaves

f. Pad thickness

g. Length (long end and short end)

h. Axle spacing center-to-center

Note: Refer to the manufacturer's parts book and/or spring manufacturer's catalog to ensure you obtain the correct parts.

☐ 12. Clean the spring seat, top plate, and new spring of all dirt and rust. Pay particular attention to removing all dirt from the hole in the spring seat which receives the center bolt. It is very important that all mating metal surfaces be clean or the u-bolts will loosen as dirt works out of the joint.

☐ 13. Obtain new u-bolts of the same type and size as originals.

☐ 14. Install new spring, making sure center bolt enters the hole in the axle seat.

☐ 15. If any shims were used, install them in original orientation.

☐ 16. Lubricate the u-bolt threads and nuts with anti-seize compound.

☐ 17. Install top plate, u-bolts, and nuts. Tighten the nuts to hold spring into place but do not torque until weight of vehicle is resting on the spring.

☐ 18. Lower frame of vehicle until all weight is resting on the springs.

☐ 19. Install and torque any spring retainer bolts, and torque the u-bolts to specs. If torque leaf spring is used, install (but do not tighten) the torque leaf bushing assembly.

☐ 20. If used, reconnect shock absorbers and torque.

☐ 21. Record the following information on the job ticket:

   a. Retainer bolts, diameter and torque

   b. U-bolts, diameter and torque

   c. Shock absorber mounting bolt torque

   Note: If springs with torque leaves were replaced, the rear axle alignment must be checked at this time.

☐ 22. Turn in job ticket when finished.

☐ 23. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________

Address ____________

Phone # ____________

Date In ____________

Date Out ____________

JOB TICKET

Customer Name ____________

Customer Address ____________

Customer Phone # ____________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________

Services/repairs made: ____________

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________ Date ____________

Technician ____________

Supervisor ____________

Unit Contents

Student Components

Student Page

Objective Sheet 3C–3
Information Sheet 3C–5

Job Sheet

1—Inspect Rear Beam Suspension Components 3C–17

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify and inspect basic rear equalizing or walking beam suspension systems and components. The student should demonstrate these competencies by completing the job sheet and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to rear beam suspension with their definitions.
2. State purposes of rear beam suspension.
3. Distinguish among the basic models of rear beam suspensions.
4. Identify the basic beam components of rear beam suspensions.
5. Match the basic components of rear beam suspensions with their correct functions.
6. Complete statements concerning the operation of rear beam suspension models and components.
7. Inspect rear beam suspension components. (Job Sheet 1)

Information Sheet

Objective 1

Terms and definitions

a. **Center bushing**—Type of bushing that provides a pivot point for the beams and connects beams to the upper portion of the suspension

b. **Cross tube**—Suspension component that restricts side movement of the axles during cornering

c. **Durometer**—Instrument that measures the hardness (stiffness) of a material such as rubber or urethane; the higher the number, the harder the material

Note: Typical rubber or urethane suspension components have durometer readings of 40, 50, 60, 70 (natural rubber), and 90.

d. **End bushing**—Type of bushing that connects the beam ends to the axles

e. **Equalizing (or walking) beam**—Forged steel or aluminum suspension component mounted to the underside of the axles; distributes weight equally between both axles

Note: As the forward rear axle goes over a two-inch bump, the center of the equalizing or walking beam is raised about one inch. This effect allows each axle to "step or walk" over bumps.

f. **Jounce**—Upward movement of the axle as the wheels go over a bump

g. **Rebound**—Downward movement of the axle as the wheels return to the road

h. **Torque rod**—Suspension component that transfers braking and driving forces to the frame and maintains drive line angularity

Objective 2

Purpose of rear beam suspension

a. To support the weight of the vehicle and its load

b. To cushion the frame and cab of the vehicle from road shocks

c. To transfer braking forces and driving forces from the axle to the frame

d. To allow axles some self alignment during cornering

e. To maintain axle alignment

f. To maintain drive line angularity

Objective 3

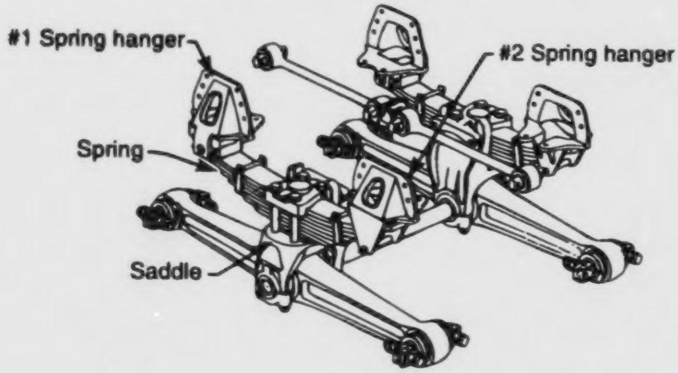
Basic models of rear beam suspension

Note: The following descriptions cover the most common Hendrickson beam-type suspensions. Check with your instructor for updated information on new models or other manufacturers as they become available.

a. **Leaf spring suspended beams**

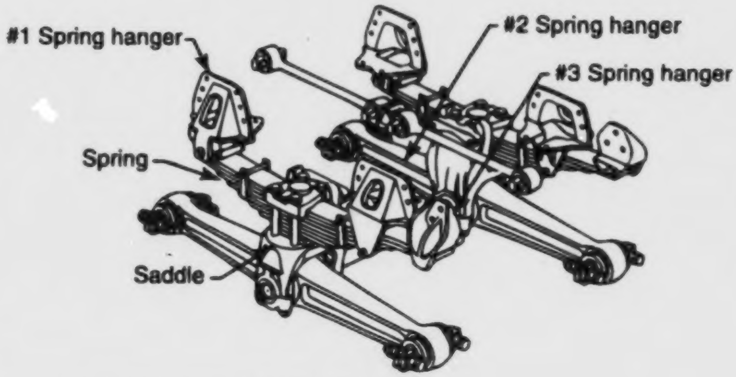
- RT2/RTE2—Used for both on or off-highway service; available in capacities from 34,000 to 52,000 lbs.

Figure 1—RT2 series suspension


#1 Spring hanger
#2 Spring hanger
Spring
Saddle

Courtesy of Hendrickson Truck Suspension Systems

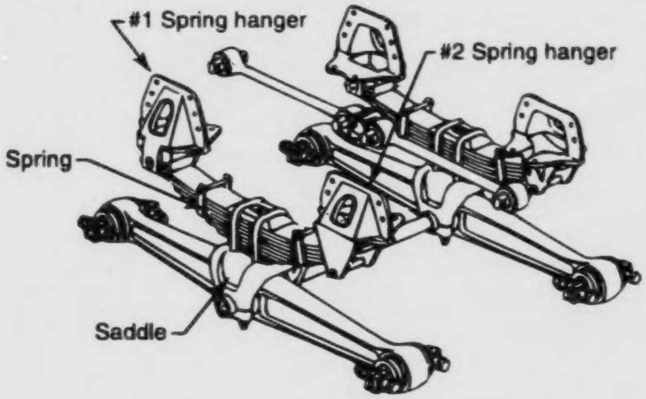
Figure 2—RTE2 series suspension


#1 Spring hanger
#2 Spring hanger
#3 Spring hanger
Spring
Saddle

Courtesy of Hendrickson Truck Suspension Systems

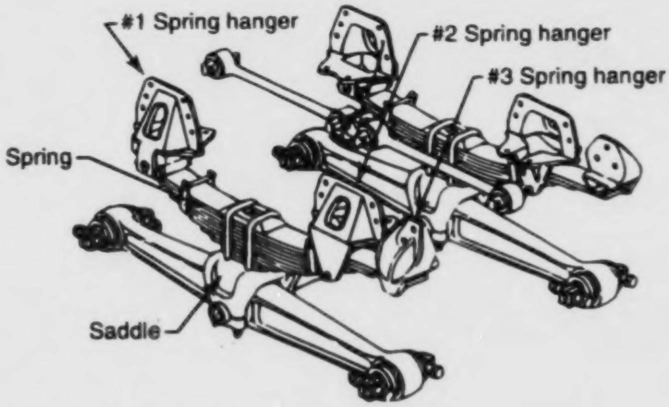
- U2/UE2—Used for on-highway service; lightweight version of the RT series

Figure 3—U2 suspension


#1 Spring hanger
#2 Spring hanger
Spring
Saddle

Courtesy of Hendrickson Truck Suspension Systems

Figure 4—UE2 suspension


#1 Spring hanger
#2 Spring hanger
#3 Spring hanger
Spring
Saddle

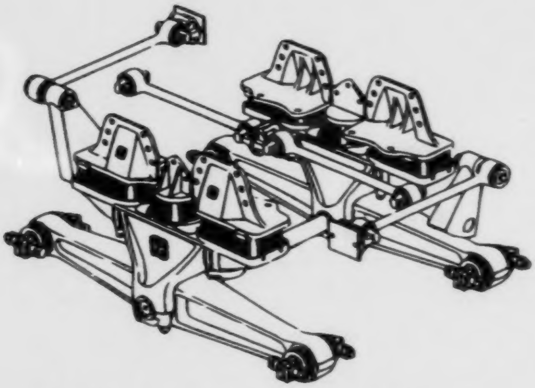
Courtesy of Hendrickson Truck Suspension Systems

BEST COPY AVAILABLE

b. **Rubber cushioned beams**

- RS series—Uses rubber load cushions to absorb shocks; available in capacities from 34,000 to 50,000 lbs.

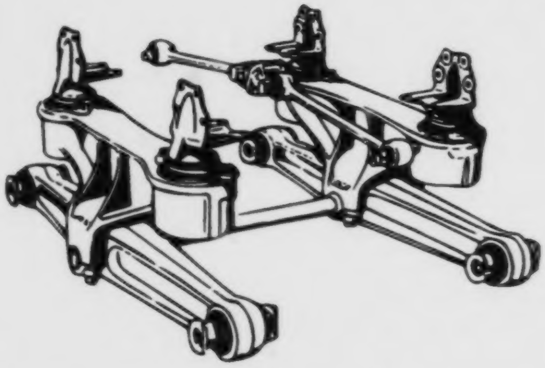
Figure 5—RS series suspension



Courtesy of Hendrickson Truck Suspension Systems

- SR series—Uses rubber shear springs to cushion the ride; available in 34,000 and 38,000 lb. capacities

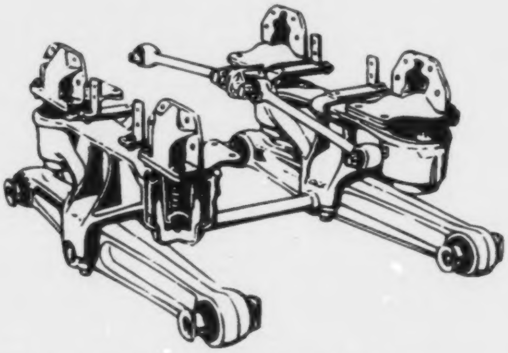
Figure 6—SR series suspension



Courtesy of Hendrickson Truck Suspension Systems

- V4 series—Uses fluid-filled rubber modules to absorb road shocks; available in capacities from 34,000 and 38,000 lb. capacities

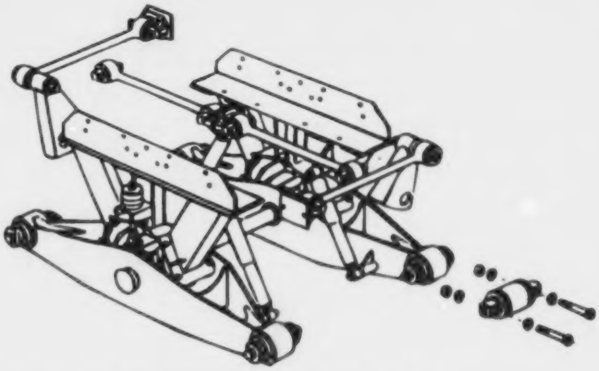
Figure 7—V4 series suspension



Courtesy of Hendrickson Truck Suspension Systems

- HN series—Uses diagonally mounted rubber bolster springs to cushion the ride; available in 40,000 to 46,000 lbs.

Figure 8—HN series suspension



Courtesy of Hendrickson Truck Suspension Systems

Objective 4

Basic beam components of rear beam suspensions

a. Equalizing (or walking) beam

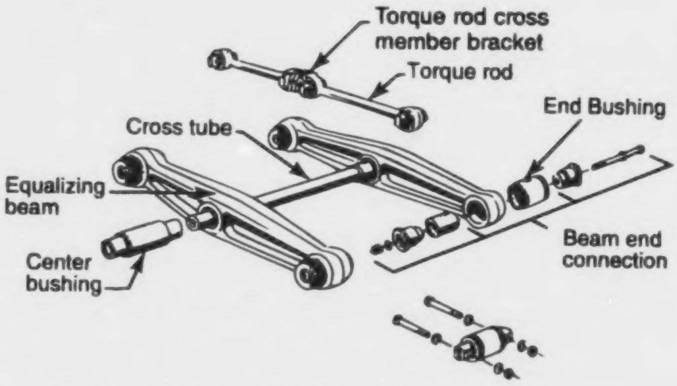
b. Center bushings

c. End bushings

d. Cross tube

e. Torque rods

Figure 9—Basic beam components



Courtesy of Hendrickson Truck Suspension Systems

Objective 5

Basic components of rear beam suspensions and their functions

a. **RT2/RTE2 and U2/UE2 series** (Figures 1-4)

- **Front hanger bracket (#1)**—Attaches the front of the spring to the frame with a spring eye pin/bushing combination; draw keys or bolts secure the pin to the bracket
- **Rear hanger bracket (#2)**—Attaches the rear of the spring to the frame; "slipper type" allowing the spring to slide as it flexes; the spring is loosely retained by a roller and bolt
- **Extended leaf bracket (#3)**—Used on RTE or UE models only; cam-shaped; contacts the top four extended leaves
- **Saddle**—Forms the mounting surface for the spring; legs clamp around the center bushing of the equalizing beams
- **Spring assembly**—Cushions the vehicle from road shocks; eye and slipper end designs

Note: RT series springs are different from U2 series springs and are NOT interchangeable.

b. **RS series** (Figure 5)

- **Rubber load cushions (four)**—Used to absorb road shocks; available in 40, 60, and 70 durometer for different applications (on or off-highway)
- **Saddle bushings**—Used to provide a flexible connection between the saddle and the frame hangers
- **Overload cushion**—Contacts the overload frame hanger after the load cushions are partially compressed; provides for a variable spring rate
- **Frame hanger**—Bolted to the frame rails to attach the load cushion to the frame; stud passes through the saddle bushings and holds the saddle to the frame
- **Saddle**—Forms the lower mounting surface for the load cushions and overload cushions; legs clamp around the center bushing of the equalizing beams

c. **SR series** (Figure 6)

- **Shear springs** (eight per suspension)—Used to absorb road shocks
- **Frame hanger**—Attaches the suspension to the frame
- **Saddle**—Forms the lower mounting surface for the shear springs; legs clamp around the center bushing of the equalizing beams

d. **V4 series** (Figure 7)

- **Elastic module** (four per suspension)—Used to absorb road shocks and provide a shock absorber effect; each unit (module) contains an internal jounce stop to prevent excessive compression of the module
- **Rebound stop**—Prevents excessive rebound travel which would put a damaging tension load on the elastic modules
- **Rebound stop hanger**—Mounts the rebound stop to the frame
- **Axle stop bracket**—Prevents excessive oscillation of the equalizing beams which could hit the underside of the module and damage it

e. **HN series** (Figure 8)

- **Rubber bolster spring**—Cushions the vehicle from road shocks; provides for a variable spring rate
- **Diagonally mounted rubber pads**—Used to absorb road shocks

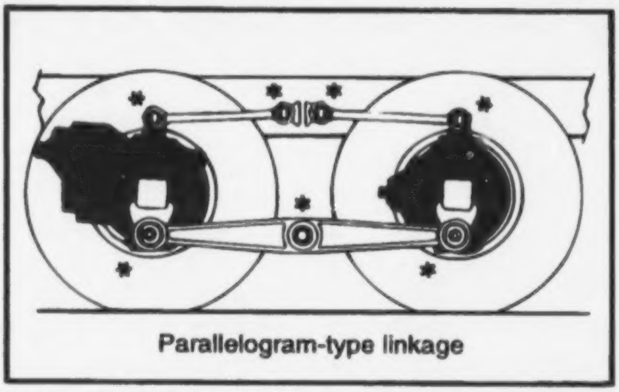
Objective 6

Operation of rear beam suspension models and components

a. Equalizing beam components

- Equalizing beams and torque rods work in a parallelogram style linkage to maintain the pinion angle (drive line angularity) of the axles.

Figure 10

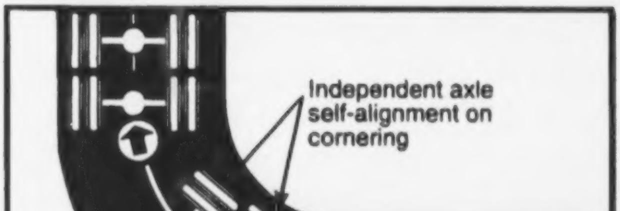


Parallelogram-type linkage

Courtesy of Hendrickson Truck Suspension Systems

- Center bushings and end bushings permit the axles some self aligning capability during cornering.

Figure 11

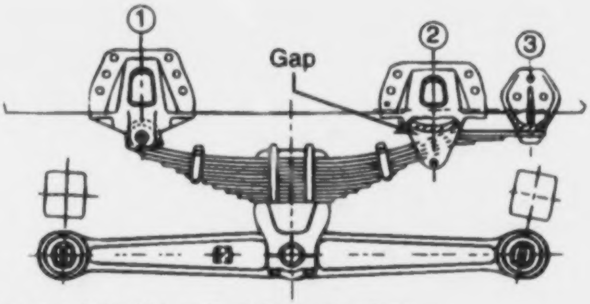


Courtesy of Hendrickson Truck Suspension Systems

b. **Extended leaf spring models (RTE2 and UE2)**

1) When the vehicle is unloaded, the top four extended leaves contact the third spring hanger. This creates a gap between the spring and the #2 hanger. The effect is a low spring rate which gives the vehicle a good ride.

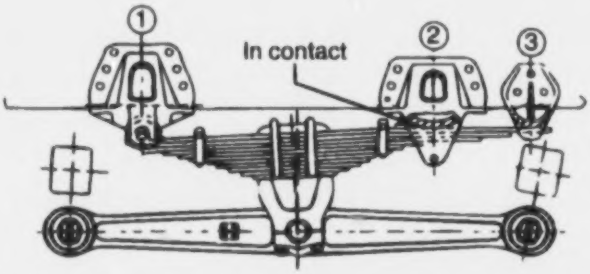
Figure 12—Spring unloaded (UE2)



Courtesy of Hendrickson Truck Suspension Systems

- When the vehicle is loaded, the extended leaves flex until the spring contacts the #2 bracket. The shorter effective length raises the spring rate so the suspension can carry a heavy load.

Figure 13—Spring loaded (UE2)

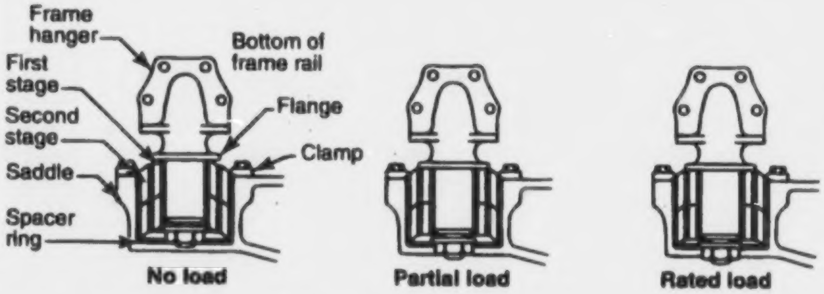


Courtesy of Hendrickson Truck Suspension Systems

c. **SR series**

- Rubber shear springs provide a two stage, variable rate suspension.
- Under no load, the inner (first stage) rubber is in shear to provide a good ride.
- As the vehicle is loaded, the flange of the frame hanger contacts a metal bushing inside the shear spring. This increases the spring rate so the vehicle can carry a heavy load.

Figure 14

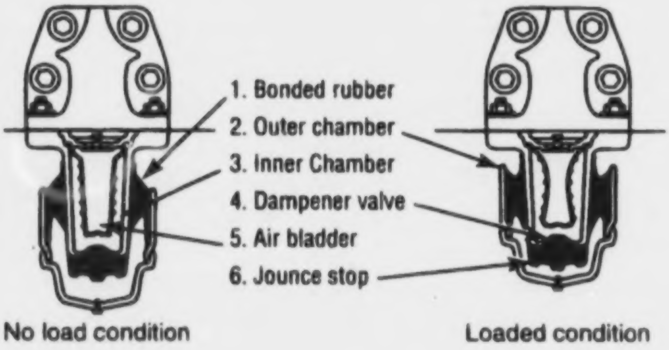

Frame hanger
Bottom of frame rail
First stage
Flange
Second stage
Clamp
Saddle
Spacer ring
No load
Partial load
Rated load

Courtesy of Hendrickson Truck Suspension Systems

d. **V4 series**

- The bonded rubber portion of the load module assembly helps to carry some of the load.
- The outer chamber contains a liquid which will be forced into the inner chamber as the vehicle is loaded. As more liquid enters the inner chamber, the air inside the bladder is compressed.
- A dampener valve controls the flow of liquid to and from the outer chamber and the inner chamber.
  - — The flowing of liquid and compressing the air cushions the load and provides for a varying spring rate.
  - — The dampener valve also acts as a shock absorber, allowing the liquid to flow into the inner chamber more quickly than out.

Figure 15—Module assemblies with frame hangers


1. Bonded rubber
2. Outer chamber
3. Inner Chamber
4. Dampener valve
5. Air bladder
6. Jounce stop
No load condition
Loaded condition

Courtesy of Hendrickson Truck Suspension Systems

Objective 7

Job Sheet 1—Inspect Rear Beam Suspension Components

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Parts are inspected accurately	______
• Specifications are accurate	______
• Findings are recorded on job ticket	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Torque wrench, ¾" drive
- Pry bar
- High pressure washer
- Floor jack
- Jack stands
- Rear beam suspension to be worked on
- Others—as recommended by instructor and equipment service manual

Guidelines

- Beam suspensions may be one of two types—spring or rubber load cushions. The equalizing (walking) beams will be inspected the same way with both systems.

- After you identify which system you are inspecting, follow the correct procedure in the service manual.

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Remove all grease and dirt from suspension area using a high pressure washer.

☐ 4. Park vehicle on a level surface, chock the front wheels, and remove the ignition key.

☐ 5. Visually inspect the rear tires checking for unusual wear patterns that may indicate incorrect alignment or worn parts.

☐ 6. Identify whether suspension is spring type (a) or rubber cushion type (b).

  ☐ a. If the suspension is a spring type, inspect the spring hanger, forward spring hanger pin, and spring eye bushings for excessive wear or damaged parts.

  ☐ b. If the suspension is a rubber cushion type, visually inspect the rubber pads or cushions for cuts or damage.

  Note: The load cushions are made of butyl and natural rubber and are not resistant to petroleum products. If the cushions become saturated with these products, they will split and disintegrate.

☐ 7. Inspect u-bolts for corrosion, missing nuts or washers, and correct torque. Use a ¾˝ drive torque wrench to check torque.

☐ 8. Inspect equalizer beam for cracks or damage.

☐ 9. Inspect equalizer beam rubber bushings for damage or deterioration. Use a pry bar to check for excessive wear.

☐ 10. Record your findings on the job ticket and get instructor approval before making a replacement.

☐ 11. Turn in job ticket when finished.

☐ 12. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ______

Address ______

Phone # ______

Date In ______

Date Out ______

JOB TICKET

Customer Name ______

Customer Address ______

Customer Phone # ______

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ______

Services/repairs made: ______

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

______ Date ______

Technician ______

Supervisor ______

Unit Contents

Student Components

Student Page

Objective Sheet 4C–3

Information Sheet 4C–5

Job Sheets

1—Inspect, Test, and Replace an Air Spring 4C–15

2—Inspect and Test an Air Suspension System, Replace the Leveling Valve, and Adjust Frame (Ride) Height 4C–19

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify, inspect, and test the rear air suspension system, replace various components, and adjust frame height. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to rear air suspension with their definitions.
2. State the purposes of rear air suspension.
3. Identify air suspension components.
4. Match air suspension components with their correct functions.
5. Identify the types of air springs.
6. Match the parts of an air spring with their correct descriptions.
7. Describe the procedure for identifying appropriate replacement air springs.
8. Distinguish among the basic valves used on rear air suspensions.
9. Identify the air ports of a leveling valve.
10. Complete statements concerning common causes of air spring failures.
11. Inspect, test, and replace an air spring. (Job Sheet 1)
12. Inspect and test an air suspension system, replace the leveling valve, and adjust frame (ride) height. (Job Sheet 2)

Information Sheet

Objective 1

Terms and definitions

a. **Air spring (air bag)**—Air-filled device that acts as a variable rate suspension spring

b. **Convolution**—Design that is shaped with curves and folds to the outside and then back to the center

c. **Failure analysis**—Systematic approach for determining the cause of a system or part failure

d. **Inversion (dump) valve**—Type of valve that releases (dumps) all of the air out of the air springs in order to lower the frame

e. **Leveling valve**—Type of valve that controls air flow into and out of the air springs to maintain a constant frame height whether loaded or empty

f. **Pressure protection valve**—Type of valve that supplies air to the suspension system from the air brake reservoir

g. **Rolling lobe (or sleeve)**—Design that is curved or rounded into a cylinder shape

h. **Spring rate**—Amount of weight required to deflect a spring one inch

i. **Transverse**—Direction that indicates objects are located crosswise to the main lengthwise axis

Example: Axles are mounted transversely to the chassis frame of the vehicle.

Objective 2

Purposes of rear air suspension

a. To support the weight of the vehicle and its load

b. To cushion the frame and cab of the vehicle from road shocks

c. To transfer braking forces and driving forces from the axle to the frame

d. To maintain a constant frame height as the vehicle is loaded or unloaded

e. To maintain axle alignment

f. To maintain drive line angularity

Objective 3

Air suspension components

a. Air springs (bags)

b. Leveling (height control) valve

c. Inversion (dump) valve (not shown)

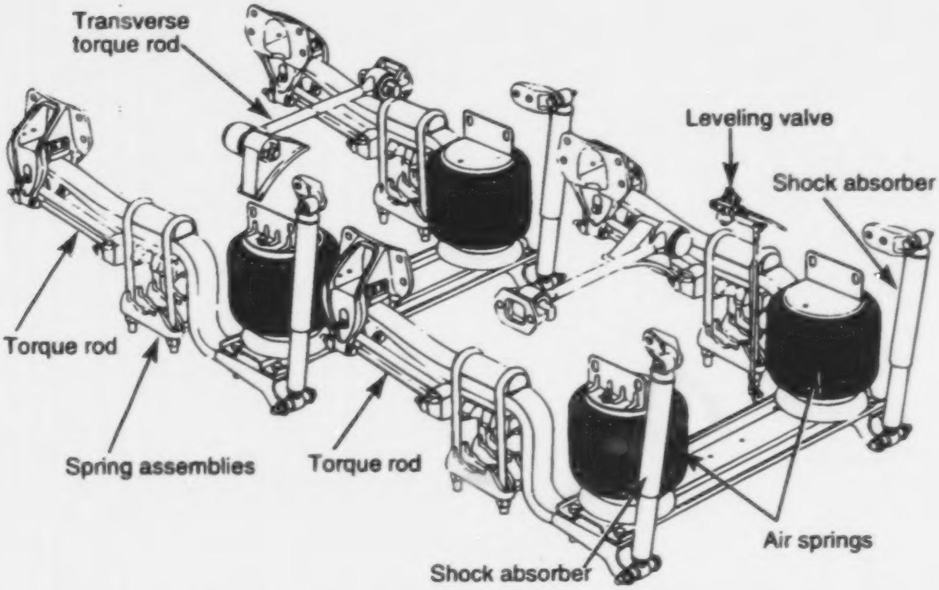
d. Pressure protection valve (not shown)

e. Spring assemblies

f. Shock absorbers

g. Torque rods

Figure 1


Transverse torque rod
Leveling valve
Shock absorber
Torque rod
Spring assemblies
Torque rod
Air springs
Shock absorber

Courtesy of Hendrickson Truck Suspension Systems

Objective 4

Functions of air suspension components

a. **Air springs (bags)**

- Serve as suspension springs with infinitely variable spring rates
- As the vehicle is loaded, the air inside the spring is compressed. The greater the air pressure in the spring, the stiffer the spring rate becomes. This lets the spring ride softly when the vehicle is empty, but still have the required weight carrying capacity.

b. **Leveling (height control) valve**

- Used to control air flow into and out of the air springs to maintain a constant frame height
- As weight is added to the vehicle during loading, the air will compress inside the air springs. As the frame begins to lower from the added weight, the leveling valve will react and allow more air into the air springs.
- During unloading of the vehicle, the frame will begin to rise. The leveling valve will react and release air from the air springs.

c. **Inversion (dump) valve**

- Used to release (or dump) all of the air out of the air springs in order to lower the frame
- Used when hooking or unhooking a trailer so the driver does not have to lift the weight of the trailer with the trailer landing gear

d. **Pressure protection valve**—Supplies air to the suspension system from the air brake reservoir

e. **Spring assemblies**

- Used in many air suspension systems as a mounting point for the air springs
- Leaf-type springs are often used with convoluted air springs. The leaf spring is very stiff and helps the air spring when the vehicle is fully loaded.
- "Hockey stick" springs are often used with rolling lobe air springs. The offset design allows a long travel air spring to be used.

f. **Shock absorbers**

- Dampen the jounce/rebound oscillations which occur when the vehicle hits a bump
- Prevent over-extension of the air spring, which could tear the flexible member of the air spring. Therefore, the extended length of shock absorbers is critical on air suspensions.
- Absolutely required on air suspensions. Air springs need shocks more than leaf springs since there is no internal friction in the air spring.

g. **Torque rods**

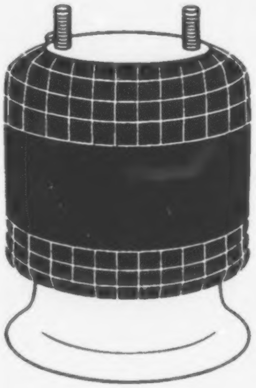
- Used in air suspensions much as they are in other suspension systems—To hold the axle in alignment and to transmit braking and driving forces to the frame
- Air suspensions may also use transverse torque rods to prevent side-to-side movement

Objective 5

Types of air springs

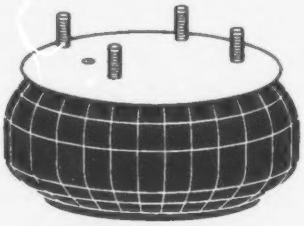
a. Rolling lobe (or sleeve)

Figure 2



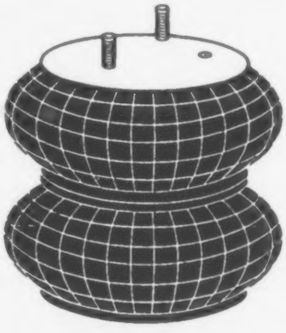
b. Single convolution

Figure 3



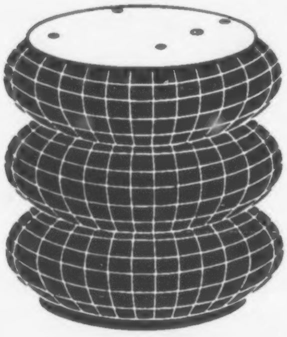
c. Double convolution

Figure 4



d. Triple convolution

Figure 5



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Objective 6

Parts of an air spring

a. **Flexible member (or bellows)**—Multi-layered flexible wall consisting of rubber and reinforced fabric

b. **Upper retainer (end) plate**—Metal plate permanently attached to the flexible member (flat plate rolls into a bead plate to hold the flexible member); contains various mounting studs and air fittings

- Standard bolt or stud—Used to attach the air spring unit to the suspension and frame
- Tapped hole (blind nut)—Alternate means of mounting the air spring by using a bolt instead of a stud
- Air fitting hole—Port for air to flow in and out of the air spring
- Combination air and mounting stud—Used to attach the air spring unit to the suspension and permits air flow to and from the air spring

c. **Piston**

- Lower plate or base on rolling lobe air springs
- Provides studs or tapped holes for mounting air spring to suspension

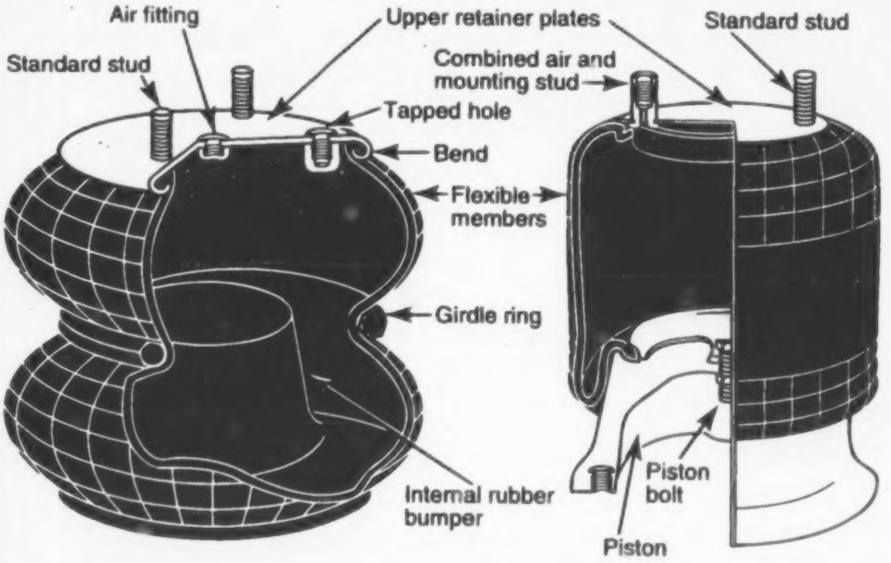
Bolted to flexible member with a piston bolt

d. **Internal rubber bumper** (optional)

- Solid molded rubber piece located inside some air springs
- Used to support the weight of the vehicle if the air spring pressure is low and to prevent damage to the suspension and vehicle

e. **Girdle ring or hoop**—Heavy duty rubber ring located between the convolutions to help provide lateral stability to the air spring

Figure 6


Air fitting
Upper retainer plates
Standard stud
Standard stud
Combined air and mounting stud
Tapped hole
Bend
Flexible members
Girdle ring
Internal rubber bumper
Piston bolt
Piston

Objective 7

Procedure for identifying appropriate replacement air springs

a. Visually identify the type of air spring.

b. Check the number molded on the rubber flexible member.

c. Measure the dimensions of the retainer plates.

- Outside diameter
- Location and dimensions of studs/blind holes and air fittings

d. Measure the collapsed height of the air spring.

Objective 8

Basic valves used on rear air suspensions

a. **Leveling valve**

- Suspension systems may use one leveling valve for each rear axle, or one valve can control the air springs on both axles.
- The valve is mounted to the frame while its actuating arm will be connected to the axle with a link.
- The actuating arm is moved up or down as the vehicle frame moves up or down because of weight changes. This action sends air into or out of the air springs.

- A time delay mechanism built into the valve prevents the valve from reacting as the suspension moves up and down over bumps. The actuating arm must remain out of the neutral position for more than 5 to 10 seconds before the valve begins to react.

- Linkage of the leveling valve is adjustable to provide the correct frame height.

b. **Inversion (dump) valve**

- Is installed between the outlet port of the leveling valve and the inlet of the air springs.

- The inversion valve control port is connected to a control valve in the dash of the vehicle. When this control valve is activated, the inversion valve blocks air from the leveling valve from going to the air springs, and exhausts all of the air in the air springs, lowering the vehicle frame.

- May also be electric over air design in which case the control is by an electrical dash switch.

- Many inversion valve controls will activate a dash light to alert the driver when air is dumped.

c. **Pressure protection valve**

- Will only allow air to flow to the suspension if pressure in the reservoir is above a safe minimum (usually about 65 to 70 psi).

- In the event of a loss of pressure in the reservoir, the pressure protection valve will close, thus conserving the remaining air for the brake system.

Objective 9

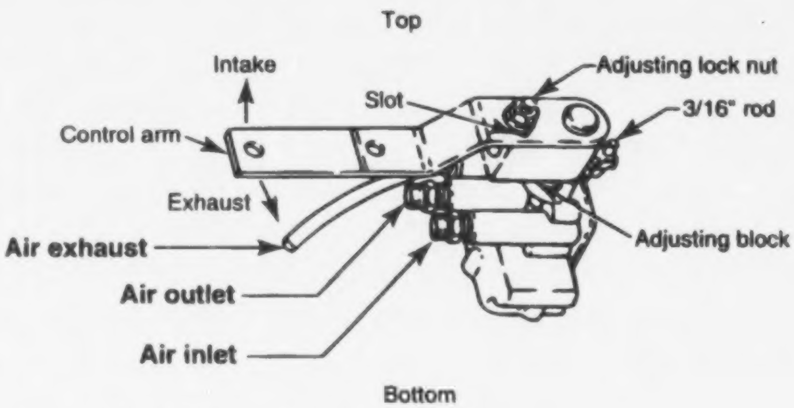
Air ports of a leveling valve

a. **Air inlet**—From the vehicle's air brake system reservoir

b. **Air outlet**—From the valve to the air springs

c. **Air exhaust**—To release air from the air springs

Figure 7



Courtesy of Peterbilt Motors Company/PACCAR inc.

Objective 10

Common causes of air spring failures

Note: Failure analysis of the air spring should help to identify one of the following causes. Early failure is usually not the fault of the air spring itself. More commonly it is abuse or improper application.

a. **Long life or use in the field**—Air springs of the proper size and design will last up to one million miles in use. However, eventually the rubber will wear in the flexing area, and the air spring will no longer hold air without leaking.

b. **Cuts or abrasion due to interference with other suspension components**—Improper installation or using springs too large in diameter for application

c. **Torn flexible member due to over-extension of the air spring;** may be caused by:

- Incorrect shock absorber (extended length of shock too long)
- Broken shock absorber or shock mounting bracket
- Incorrect air spring for the application

Note: Protect the air springs from over-extension before jacking up the frame. Be sure shocks are in place or chain the suspension to the frame.

d. **Driving the vehicle with no air in the air springs**—May cause the blind nut inside the retainer plate to quickly wear a hole in the flexible member.

Note: Air springs with an internal rubber bumper will not have this problem.

Objective 11

Job Sheet 1—Inspect, Test, and Replace an Air Spring

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Parts are inspected accurately	______
• Specifications are accurate	______
• Findings are recorded on job ticket	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Torque wrench
- Soapy water
- Wheel chocks
- Floor jack
- Jack stands
- Rear air suspension to be worked on
- Others—as recommended by instructor and equipment service manual

Guidelines

- Follow all safety procedures outlined in the service manual.
- Always use correct replacement parts. Never modify or substitute parts not recommended because the part may not meet the manufacturer's specifications and could result in loss of vehicle control.

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Move vehicle to level floor area, set the parking brake, and remove the ignition key.

☐ 4. With air pressure at 120 psi, test air spring for leaks. You may need to use soapy water to locate the leak. Record on job ticket.

☐ 5. Inspect all components that are used in the operation of the air suspension for wear and damage. Refer to the manufacturer's service manual. Record findings on job ticket.

☐ 6. After you locate the air spring that needs to be replaced, chock the front wheels so vehicle cannot roll.

STOP! Get instructor approval before continuing.

Correct air spring is identified: __________ (instructor initials)

☐ 7. Unhook height control valve linkage to dump air pressure from air springs.

☐ 8. Raise frame of vehicle to remove load from suspension and install jack stands.

☐ 9. Remove locknuts and washers which connect air spring to air spring mounting bracket.

☐ 10. Remove air line to air spring and brass air fittings from air spring.

☐ 11. Remove locknuts and washers which connect air spring to air spring frame hanger and remove air spring.

STOP! Get instructor approval before continuing. ______ (instructor initials)

☐ 12. Reassemble air spring in reverse procedure. Use manufacturer's service manual for correct procedure and torque specifications.

☐ 13. Turn in job ticket when finished.

☐ 14. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE
	TOTAL PARTS/MATERIALS	

SPECIFICATIONS CHECKED

School/Work Name ____________________

Address ____________________

Phone # ____________________

Date In ____________

Date Out ____________

JOB TICKET

Customer Name ____________________

Customer Address ____________________

Customer Phone # ____________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________________

Services/repairs made: ____________________

LABOR

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________________ Date ____________

Technician ____________

Supervisor ____________

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Objective 12

Job Sheet 2—Inspect and Test an Air Suspension System, Replace the Leveling Valve, and Adjust Frame (Ride) Height

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Parts are inspected accurately	______
• Specifications are accurate	______
• Findings are recorded on job ticket	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Tape measure
- Soapy water
- Rear air suspension to be worked on
- Others—as recommended by instructor and equipment service manual

Guidelines

- Follow all safety procedures outlined in the service manual.
- Inspection and adjustment should be performed on an unloaded vehicle.

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Move vehicle to level floor area

☐ 4. Free and center all suspension joints by slowly moving vehicle back and forth several times without using the brakes. When coming to a complete stop, make sure the brakes are released.

☐ 5. With air system pressure at 120 psi, remove ignition key and chock front wheels.

☐ 6. Inspect lines, fitting, and valves for looseness and damage.

☐ 7. Test lines, fitting, and valves for air leaks using the soapy water. Record on job ticket.

☐ 8. Purge the air pressure from the suspension system, and then remove the air lines from the leveling valve.

☐ 9. Remove the leveling valve link from the valve by removing nut and washer. Procedures differ so use the correct manufacturer's service manual for procedure.

☐ 10. Remove locknuts, washers, and bolts which connect leveling valve to frame.

☐ 11. Remove brass air fittings from leveling valve.

☐ 12. Install brass air fitting into new leveling valve.

☐ 13. Assemble bolts, washers, and locknuts which connect valve to frame.

☐ 14. Connect air lines to leveling valve.

☐ 15. Assemble leveling valve threaded extension rod to leveling valve and assemble lock washer and nut.

☐ 16. Air up system and release parking brakes.

☐ 17. Adjust leveling valve for proper ride height using the correct procedure in the service manual.

☐ 18. Turn in job ticket when finished.

☐ 19. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ______

Address ______

Phone # ______

Date In ______

Date Out ______

JOB TICKET

Customer Name ______

Customer Address ______

Customer Phone # ______

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ______

Services/repairs made: ______

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

______ Date ______

Technician ______

Supervisor ______

Unit Contents

Student Components

Student Page

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Information Sheet 5C–5

Job Sheets

1—Perform Pre-alignment Checks 5C–17
2—Check Camber and Kingpin Inclination; Determine Needed Repairs 5C–21
3—Check Caster; Adjust or Repair as Needed 5C–25
4—Check Toe; Adjust as Needed 5C–29
5—Check Rear Axle Alignment; Adjust or Repair as Needed 5C–33
6—Measure and Adjust Pinion Angle 5C–39

Objective Sheet

Unit Objective

After completing this unit, the student should be able to perform basic vehicle alignment checks and adjustments. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to vehicle alignment with their definitions.
2. List purposes of vehicle alignment.
3. Discuss required times to perform front wheel alignment.
4. Complete statements concerning toe-in and toe-out.
5. Distinguish between true and false statements concerning caster.
6. Complete statements concerning camber.
7. Distinguish between true and false statements concerning kingpin inclination.
8. Complete statements concerning maximum turning angle.
9. Distinguish between true and false statements concerning turning radius angle (Ackermann angle).
10. Complete statements concerning axle alignment.
11. Complete statements concerning pinion angle adjustment.
12. Distinguish between a minor and a major front wheel alignment.
13. Perform pre-alignment checks. (Job Sheet 1)
14. Check camber and kingpin inclination; determine needed repairs. (Job Sheet 2)
15. Check caster; adjust or repair as needed. (Job Sheet 3)
16. Check toe; adjust as needed. (Job Sheet 4)
17. Check rear axle alignment; adjust or repair as needed. (Job Sheet 5)
18. Measure and adjust pinion angle. (Job Sheet 6)

Information Sheet

Objective 1

Terms and definitions

a. **Alignment**—Adjustments made in the relationship between axles, steering and suspension components, and tires to bring them into correct positions

b. **Camber**—Inward or outward tilt of the top of the tires when viewed from the front of the vehicle

c. **Caster**—Forward or rearward tilt of the kingpin centerline when viewed from the side of the vehicle

d. **Kingpin inclination** (KPI)—Angle measured between the centerline of the kingpin and the vertical position as viewed from the front of the vehicle

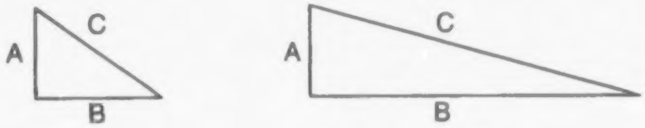
e. **Maximum turning angle**—Degree of movement from a straight-ahead position of the front wheels to either an extreme right or left position; adjusted by stop screws on the steering knuckle

f. **Pinion**—Name of a smaller gear and shaft designed to mesh with a larger gear and shaft

g. **Pinion angle**—Angle between pinion shaft and frame

h. **Pythagorean theorem**—Geometry formula that applies only to right (90°) triangles that states: $A^2 + B^2 = C^2$

Figure 1



Example 1: If $A = 3$, $B = 4$, solve for C

$$3^2 + 4^2 = 9 + 16 = 25 = C^2$$

$$\sqrt{25} = 5 = C$$

Example 2: If $A = 2$, $B = 6$, solve for C

$$2^2 + 6^2 = 4 + 36 = 40 = C^2$$

$$\sqrt{40} = 6.32 = C$$

Note: The Pythagorean theorem can be used to prove whether or not you have a right triangle, and therefore, whether or not axles are 90° to the frame and in alignment.

i. **Scrubbing**—Condition of tires subjected to extreme friction, especially from misalignment

j. **Thrust**—Force that moves an object forward

k. **Thrust angle**—Angle between thrust lines and vehicle's centerline

l. **Thrust lines**—Marks or tracks that indicate forward movement of the rear wheels; should be parallel to vehicle's centerline

m. **Toe**—Angle of the tires from the true straight-ahead position when viewed from the top of the vehicle

n. **Turning radius angle**—Characteristic angle built into the steering linkage by the manufacturer to allow for the different radii used by the front wheels during a turn

Note: Because the inner wheel of a vehicle must follow a smaller circle than the outer wheel, the inner and outer wheels must turn at different angles. This is sometimes referred to as the steering geometry or Ackermann angle.

Objective 2

Purpose of wheel alignment

a. To correct steering and tire wear conditions

b. To maintain reliable and stable steering

c. To maintain steering handling

d. To maximize life of tires and suspension parts

Objective 3

Required times to perform front wheel alignment

a. Every 200,000 miles (320,000 km) or 24 months (normal maintenance)

b. When the vehicle does not steer correctly

c. When tires are wearing rapidly or unusually

d. After extremely heavy service or severe impact loads

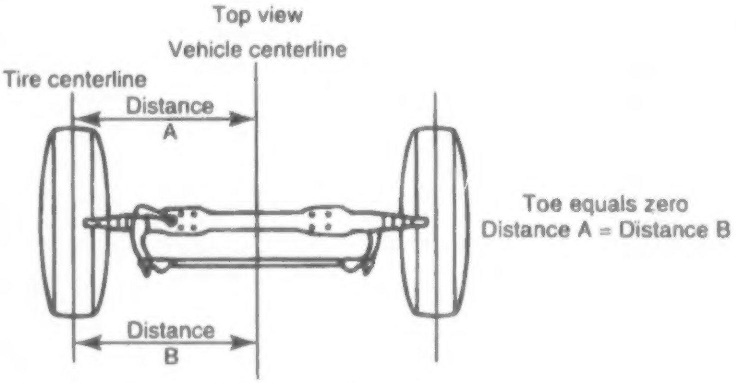
Objective 4

Toe-in and toe-out

a. Toe is the angle of the tires from the true straight-ahead position when viewed from the top of the vehicle.

- When the tire centerline is parallel with the vehicle centerline, the toe is equal to zero.

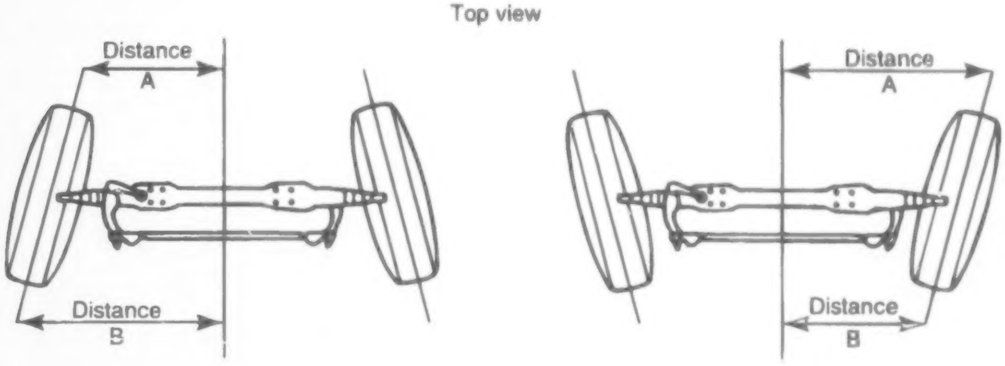
Figure 2


Top view
Vehicle centerline
Tire centerline
Distance A
Toe equals zero
Distance A = Distance B
Distance B

Courtesy of Rockwell Heavy Vehicle System, Inc.

- When the front end of the tire points inward toward the vehicle, the tire has toe-in.
- When the front of the tire points outward from the vehicle, the tire has toe-out.

Figure 3


Top view
Distance A
Distance B
Distance A
Distance B

Toe-in
Distance A < Distance B

Toe-out
Distance A > Distance B

Courtesy of Rockwell Heavy Vehicle System, Inc.

b. Toe-in is designed into the vehicle by the manufacturer to counteract the natural tendency of the tires to toe-out when the vehicle is driven.

c. Incorrect toe angles usually do not affect directional stability of the vehicle. However, incorrect toe will result in rapid tire wear. In fact, most tire wear is caused by incorrect toe settings.

  - Too much toe-in wears the outer edges of tires.
  - Too much toe-out wears the inner edge of tires.

d. Toe is calculated in either degrees, inches, or millimeters.

e. Measuring toe involves marking tires with paint or chalk and measuring the front and back of tires with a trammel bar. If the toe measurement is not within specifications, the cross tube or tie rod ends will need to be adjusted. Refer to the vehicle manufacturer's instructions for specifications and procedure.

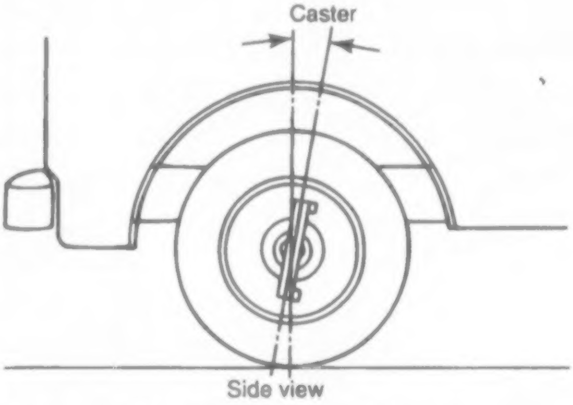
Objective 5

Caster

a. Caster is the forward or rearward tilt of the kingpin centerline when viewed from the side of the vehicle.

  - Positive caster indicates the kingpin is tilted rearward.
  - Negative caster indicates the kingpin is tilted forward.

Figure 4



Courtesy of Rockwell Heavy Vehicle System, Inc.

b. Caster is a directional stability angle only. Incorrect caster by itself does not affect tire wear.

c. Caster angle helps the driver return the front wheels to a straight ahead position.

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d. When two wheels have different caster angles, the vehicle pulls in the direction of the wheel with more negative caster or less caster if both are positive.

e. Use an alignment machine to check this angle. Refer to the equipment manufacturer's directions for operating the machine.

f. Possible causes of incorrect caster are weak (sagging) or broken springs, bent or twisted axle, or unequally tightened spring u-bolts.

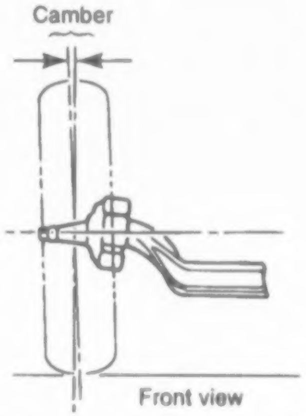
g. Caster is adjusted with tapered shims (wedge-shaped caster plates) installed between the leaf springs and the axle. Adjust caster according to vehicle manufacturer's instructions.

Objective 6

Camber

a. Camber is the inward or outward tilt of the top of the tires when viewed from the front of the vehicle.

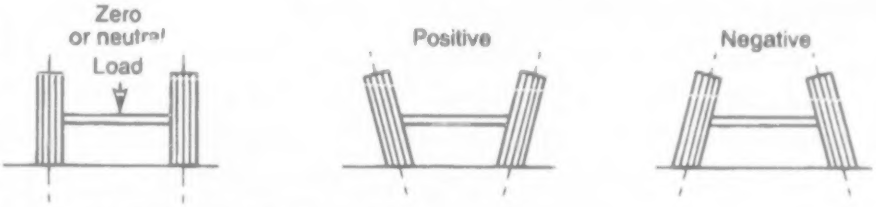
Figure 5



Courtesy of Rockwell Heavy Vehicle System, Inc.

- If the top of the tire tilts outward, it has positive camber.
- If the top of the tire tilts inward, it has negative camber.

Figure 6



Courtesy of Rockwell Heavy Vehicle System, Inc.

b. Incorrect camber angles affect both directional stability and tire wear.

c. If there is significant difference in camber from one side of the vehicle to the other, the vehicle will pull to the side with the greater amount of positive camber.

d. Excessive positive camber causes the tire to wear on its outside shoulder.

e. Excessive negative camber causes the tire to wear on its inside shoulder.

f. Use an alignment machine to check this angle. Refer to the equipment manufacturer's directions for operating the machine.

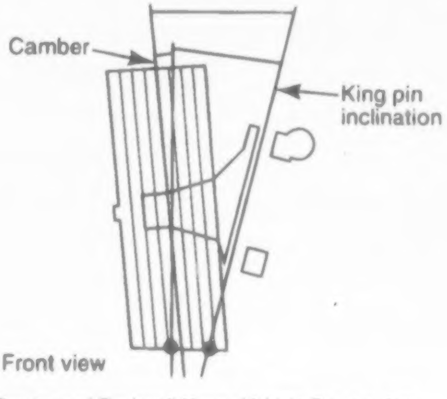
g. The camber angle is NOT adjustable. This angle is machined into the axle beam. If the camber angle is not within specifications, check the axle beam and steering knuckle for damage. Service as necessary.

Objective 7

Kingpin inclination (KPI)

a. This is the angle measured between the centerline of the kingpin (knuckle pin) and the vertical position as viewed from the front of the vehicle.

Figure 7



Courtesy of Rockwell Heavy Vehicle System, Inc.

b. Kingpin inclination and camber angle put the approximate center of the tire tread in contact with the road. This reduces steering effort and improves directional stability.

c. Use an alignment machine to check this angle. Refer to the equipment manufacturer's directions for operating the machine.

d. The kingpin inclination is NOT adjustable. If the inclination is not within specifications, check the axle beam, kingpin, knuckle, or spindles for damage. Service as necessary. DO NOT bend axle to alter dimension.

Objective 8

Maximum turning angle

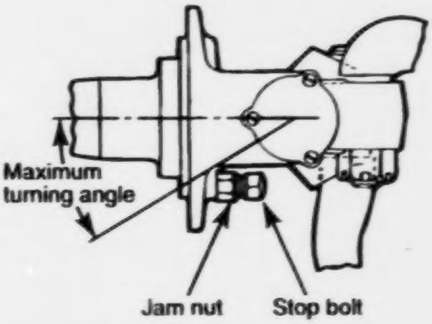
a. This is the degree of movement from a straight-ahead position of the front wheels to either an extreme right or left position.

b. This angle can be adjusted ONLY if the manufacturer of the vehicle specifies the adjustment. Never increase this angle.

c. Use an alignment machine to check this angle. Refer to the equipment manufacturer's directions for operating the machine.

d. Adjustable stop screws located on the steering knuckle control this angle. Refer to the service manual for the correct adjustment procedure.

Figure 8



Courtesy of Rockwell Heavy Vehicle System, Inc.

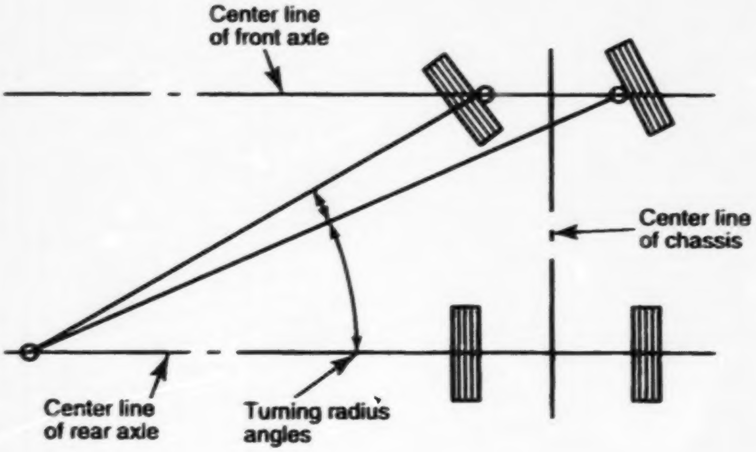
e. Proper turning angle prevents the tires from rubbing against the nearest point on the chassis or the steering gear from bottoming.

Objective 9

Turning radius angle (Ackermann angle or toe-out on turns)

a. During a turn, the inner wheel of a vehicle must follow a smaller circle than the outer wheel. This means the inner and outer wheels must turn at different angles. This angle is called the turning radius angle (or Ackermann angle).

Figure 9



Courtesy of Rockwell Heavy Vehicle System, Inc.

b. This angle is built into the design of the tie rod arms, the tie rod ends, and the cross tube assembly by the manufacturer to give the best possible road contact and to minimize tire wear during turns.

c. This angle can be checked using an alignment machine with radius plates. Refer to the equipment manufacturer's directions for checking this angle.

d. If this angle is not within specifications, inspect the knuckle, tie rod arms, tie rod ends, and cross tube for wear and damage. Service as necessary.

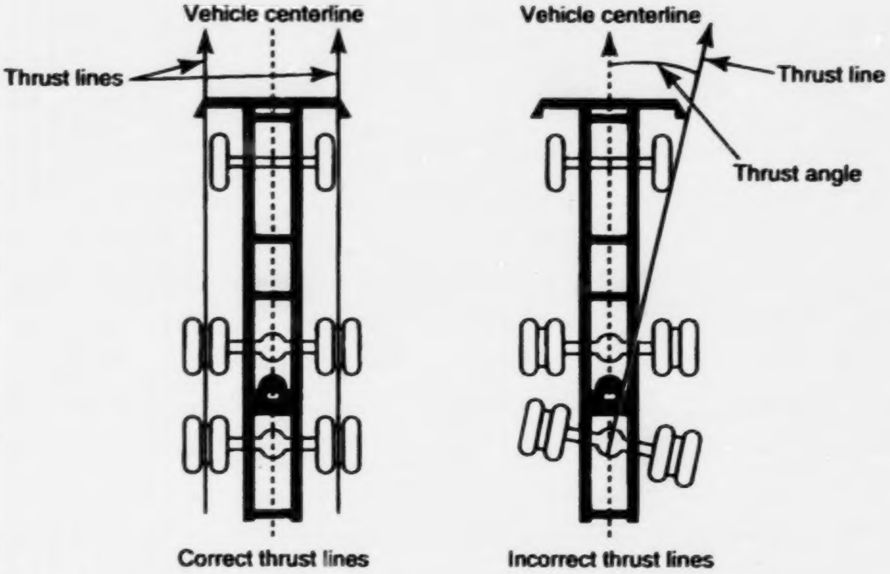
Objective 10

Axle alignment

a. Ideally, the vehicle's axles should be perpendicular to the vehicle centerline and the rear wheels should track directly behind the front wheels when the vehicle is moving straight ahead. When this happens, the thrust line created by the rear wheels is parallel to the vehicle centerline.

b. If the axles are not perpendicular to the vehicle centerline, the rear wheels do not track directly behind the front wheels and the thrust line of the rear wheels deviates from the centerline of the vehicle.

Figure 10



Courtesy of Rockwell Heavy Vehicle System, Inc.

c. Any deviation between the centerline and the thrust line is known as the thrust angle.

- Positive thrust angle—Tracking to the right
- Negative thrust angle—Tracking to the left

d. Tandem axle vehicles will have a thrust line for each rear axle.

e. Axles out of alignment can cause the steering wheel to rest in an uncentered position, the front tires to scrub and wear quickly, and the vehicle to oversteer when turning in one direction and understeer when turning in the other direction.

Objective 11

Pinion angle adjustment

a. **Basic terminology**

- **Pinion angle**—Slope of the centerline of the axle pinion shaft

  Note: Most rear axles are installed with the pinion sloping downward.

- **Drive shaft slope**—Angle of centerline of the driveshaft

- **Engine/transmission slope**—Angle of the centerline of the crankshaft/transmission mainshaft

  Note: Most engines/transmissions are installed sloping downward.

- **Working angle of the transmission u-joint**—Difference in angles between the engine slope and the drive shaft slope

- **Working angle of the rear axle u-joint**—Difference between the drive shaft slope and the pinion angle

b. **Adjustments**

- **Working angles** (4 and 5 above)—Must be held within one degree of each other to prevent driveline vibration problems

- **Pinion angle**—May be adjusted by changing the angle of the axle seat or using tapered axle shims similar to caster shims used on front axles

  Note: On some rear suspensions pinion angle can be adjusted with torque rods which connect the top of the axle to a frame cross member.

Objective 12

Minor and major front wheel alignments

a. **Minor front wheel alignment**—for all normal maintenance conditions

- Inspect all systems that affect wheel alignment—tire wear and inflation, wheel bearings, tie rods, steering gear, shock absorbers
- Check and adjust wheel bearings.
- Check and adjust toe-in.

b. **Major front wheel alignment**—to correct steering and tire wear conditions

- Inspect all systems that affect wheel alignment—tire wear and inflation, wheel bearings, tie rods, steering gear, shock absorbers
- Check and adjust wheel bearings.

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- Check and adjust maximum turning angle.
- If vehicle has power steering, check and adjust pressure relief in power steering system.
- Check turning radius angle (Ackermann angle).
- Check kingpin inclination.
- Check camber angle.
- Check and adjust caster angle.
- Check and adjust toe-in.

Objective 13

Job Sheet 1—Perform Pre-alignment Checks

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Parts are inspected accurately	______
• Specifications are accurate	______
• Findings are recorded on job ticket	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Tire pressure gauge
- Tire tread depth gauge
- Dynamic balancer
- Vehicle needing alignment checked
- Others—as recommended by instructor and equipment service manual

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Check all tires. They should be at their recommended inflation pressures.

☐ 4. Check front tires. They should match in size, type, number of plies, and amount of wear.

☐ 5. Check rims. They should be the same size and type.

☐ 6. Check rear tires. They should match in size, number of plies, and amount of wear.

Note: Tire size from front to back may vary.

☐ 7. Balance all wheel, hub, drum, and tire assemblies in dynamic balancer.

☐ 8. Check wheel bearings and steering knuckle pin bushings for wear and defects.

☐ 9. Check axle. It should be straight, not bent or twisted.

☐ 10. Check for broken or sagging springs, loose spring clips, loose axle clamping plates and wear on front spring center bolt.

☐ 11. Check entire steering gear assembly for wear, looseness, endplay, lubrication, and centering of steering gear.

☐ 12. Make necessary corrections, adjustments, or replacements as approved. Record on job ticket.

☐ 13. Turn in job ticket when finished.

☐ 14. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

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PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name __________
Address __________
Phone # __________

Date In __________
Date Out __________

JOB TICKET

Customer Name __________
Customer Address __________
Customer Phone # __________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: __________

Services/repairs made:	LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

__________ Date __________

Technician __________
Supervisor __________

Objective 14

Job Sheet 2—Check Camber and Kingpin Inclination; Determine Needed Repairs

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Parts are inspected accurately	______
• Specifications are accurate	______
• Findings are recorded on job ticket	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Appropriate alignment equipment procedure manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Wheel chocks
- Floor jack
- Jack stands
- Camber/caster gauges and turntables
- Vehicle needing alignment checked
- Others—as recommended by instructor and equipment service manual

Guidelines

- The amount of camber used depends on the amount in degrees the kingpin is inclined.

- There is no means of adjusting camber and kingpin inclination if the vehicle is equipped with a straight axle beam. The angles will not change unless the axle has been bent. If angles are incorrect, replace the axle.

- Remember, positive camber is when the top of the tire tilts outward, and negative camber is when the top of the tire tilts inward.

Procedure

☐ 1. Locate and follow the appropriate procedures in the service manual and the alignment equipment procedure manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Move vehicle to level floor area, set parking brake, and remove ignition key.

☐ 4. Raise front wheels off the floor.

☐ 5. Inspect wheel bearings and kingpin bushing for slack and incorrect adjustment.

☐ 6. Check tire inflation to make sure it is correct.

☐ 7. Place turntable under each front wheel.

☐ 8. Lower vehicle making sure the tires contact the center of the turntables.

☐ 9. Remove jack.

☐ 10. Turn the steering wheel so the front wheels face straight ahead.

☐ 11. Install the wheel clamp to the wheel and the camber gauge to the wheel clamp following the manufacturer's directions.

☐ 12. Record your findings on the job ticket and report any needed repairs on the job ticket.

☐ 13. Turn in job ticket when finished.

☐ 14. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

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PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ______
Address ______
Phone # ______

Date In ______
Date Out ______

JOB TICKET

Customer Name ______
Customer Address ______
Customer Phone # ______

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ______

Services/repairs made: ______

LABOR

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

______ Date ______

Technician ______
Supervisor ______

Objective 15

Job Sheet 3—Check Caster; Adjust or Repair as Needed

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Parts are inspected accurately	______
• Specifications are accurate	______
• Findings are recorded on job ticket	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Appropriate alignment equipment procedure manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Wheel chocks
- Floor jack
- Jack stands
- Camber/caster gauges and turntables
- Vehicle needing alignment checked
- Others—as recommended by instructor and equipment service manual

Guidelines

- Too little caster can cause wheel instability, wandering, and poor wheel recovery. Too much caster can result in hard steering, darting, oversteering, and low speed shimmy.

- Adjustment of caster angles is achieved by the insertion of tapered shims between the springs and spacer blocks.

- Remember, positive caster indicates the kingpin is tilted rearward, and negative caster indicates the kingpin is tilted forward.

Procedure

☐ 1. Locate and follow the appropriate procedures in the service manual and the alignment equipment procedure manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Move vehicle to level floor area, set parking brake, chock wheels, and remove ignition key.

☐ 4. Raise front wheels off the floor.

☐ 5. Inspect wheel bearings and kingpin bushing for slack and incorrect adjustment.

☐ 6. Check tire inflation to make sure it is correct.

☐ 7. Place turntable and turning radius gauge under each front wheel.

☐ 8. Lower vehicle making sure the tires contact the center of the turntables.

☐ 9. Remove jack.

☐ 10. Turn the steering wheel so the front wheels face straight ahead.

☐ 11. Install the wheel clamp to the wheel and the caster gauge to the wheel clamp following the manufacturer's directions.

  ☐ a. If the caster difference from side to side exceeds 1/2 degree, the axle is probably twisted.

  ☐ b. To change caster angle setting, follow the procedure in the manufacturer's service manual to change caster shims.

  ☐ c. Use only one shim on each side. Do not stack them.

☐ 12. Record your findings on the job ticket and report any needed repairs on the job ticket.

☐ 13. Turn in job ticket when finished.

☐ 14. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name __________

Address __________

Phone # __________

Date In __________

Date Out __________

JOB TICKET

Customer Name __________

Customer Address __________

Customer Phone # __________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: __________

Services/repairs made: __________

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

__________ Date __________

Technician __________

Supervisor __________

Objective 16

Job Sheet 4—Check Toe; Adjust as Needed

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Parts are inspected accurately	______
• Specifications are accurate	______
• Findings are recorded on job ticket	______

Basic Skills

Reading Writing Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Appropriate alignment equipment procedure manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Wheel chocks
- Floor jack
- Jack stands
- Toe-in gauge (beam trammel with sliding pointer)
- Chalk and scribe
- Vehicle needing alignment checked
- Others—as recommended by instructor and equipment service manual

Guidelines

- Toe-in must be measured with the weight of the vehicle on the front wheels.
- Always recheck toe-in after any change in caster or camber angle or after any alteration in tie-rod adjustment.

Procedure

☐ 1. Locate and follow the appropriate procedures in the service manual and the alignment equipment procedure manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Move vehicle to level floor area, set parking brake, chock wheels, and remove ignition key.

Note: The following procedure is recommended for vehicles equipped with a straight axle beam. Use the correct manufacturer's service manual for procedure, specifications, and additional information.

☐ 4. Whiten a small area (about 3" x 3") on the front and rear of each front tire using a piece of chalk. The center of each whitened area should fall approximately on a horizontal line passing through the center of the wheel.

☐ 5. Jack up the front end so the tires are just free to turn. Point the wheels as close to straight ahead as is possible by eye.

☐ 6. Position a pointed scribe, against the center of the thread of one tire, so that it just contacts the rubber in the middle of a chalked area.

☐ 7. Carefully rotate the tire one revolution, thus scribing a circumferential gauge line.

☐ 8. Repeat this for both front tires.

☐ 9. Rotate the front tires until the chalked areas are positioned front and rear for both tires.

☐ 10. Lower the front end to the floor so the weight of the vehicle is on the tires.

☐ 11. Making sure front tires are still pointing straight ahead, use a beam trammel to determine the distance between the scribe lines on the forward side of the tires.

  ☐ a. Lock the pointers in place.

  ☐ b. Move to the rear side of the tires.

  ☐ c. Place one pointer on the rear side of the right-hand tire directly on the scribed line in the middle of the white chalk area.

  ☐ d. Place the other pointer on the rear side of the left-hand tire and measure the difference.

☐ 12. Refer to manufacturers specifications for proper toe-in values.

  ☐ a. If adjustment is required, loosen the tie rod clamps and turn the tie rod in the required direction.

  ☐ b. Repeat step 11 to recheck toe-in.

☐ 13. After obtaining the proper setting, tighten the tie-rod clamps.

☐ 14. Record your findings on the job ticket and report any needed repairs on the job ticket.

☐ 15. Turn in job ticket when finished.

☐ 16. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Job Sheet 4

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ________________
Address ________________
Phone # ________________

Date In ________
Date Out ________

JOB TICKET

Customer Name ________________
Customer Address ________________
Customer Phone # ________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ________________

Services/repairs made:	LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

________________ Date ________

Technician ________
Supervisor ________

Objective 17

Job Sheet 5—Check Rear Axle Alignment; Adjust or Repair as Needed

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Directions are followed	______
• Safety procedures are followed	______
• Trammel bar is clamped square to frame	______
• Axle alignment is accurately measured	______
• Torque specifications are accurate	______

Basic Skills

Reading Writing Mathematics Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Plumb bobs, 2
- Carpenter's framing squares, 2
- Trammel bar
- Straight bar stock (3/8 x 1-1/2), 9-foot length
- C-clamps, 2
- Tape measure
- Torque wrench
- Vehicle needing alignment checked
- Others—as recommended by instructor and equipment service manual

Guidelines

- Rear axles must be square to the frame (within 1/8") or the vehicle will pull to left or right and tires will wear out prematurely.

- The trammel bar method given here will show how axle alignment is checked and adjusted.

- Rear axle alignment may also be checked with sophisticated electronic and laser equipment.

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

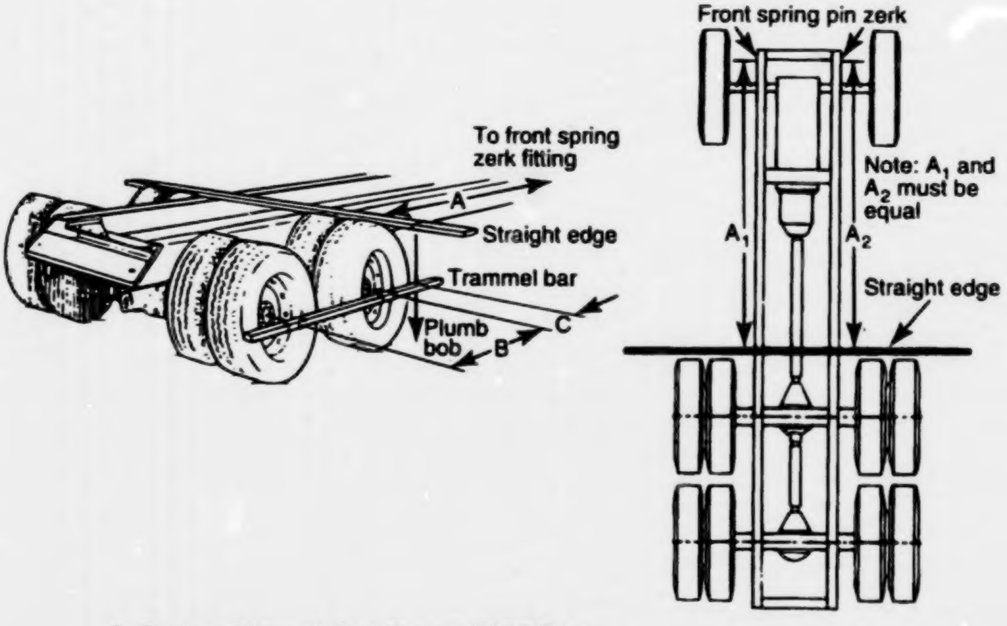
☐ 3. Drive vehicle onto a level floor. The suspension must be in a "settled" position. This is done by driving forward at least 20 feet and leaving the park brakes released. You may have to supply the vehicle air brake system with shop air to prevent the park brakes from applying as the air system pressure drops.

☐ 4. Chock the front wheels to prevent the vehicle from rolling, and remove the ignition key.

☐ 5. Clamp a length of straight bar stock at least 9 feet long across the frame rails, just behind the cab. This bar must be perpendicular to the frame rails and extend beyond the width of the outer tires. The bar may be squared up in several ways:

  ☐ a. Suspend a plumb bob from the grease zerk of each front spring pin on the steering axle and mark the bob position on the floor. Then measure back equal amounts on each side and mark the floor under the bar stock. Suspend a plumb bob from each end of the bar stock and adjust the bar until bobs match the mark on the floor.

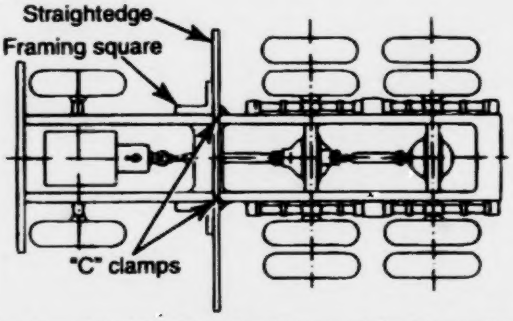
Figure 1


To front spring zerk fitting
A
Straight edge
Trammel bar
Plumb bob
B
C
Front spring pin zerk
Note: A_1 and A_2 must be equal
A_1
A_2
Straight edge

Courtesy of Kenworth Truck Company/PACCAR Inc.

☐ b. Use carpenter's framing squares to position the bar stock square to the frame rails. Measure the distance between frame rails at several points to make sure they are parallel. Frame rail dimensions often vary as crossmembers weaken or become loose.

Figure 2

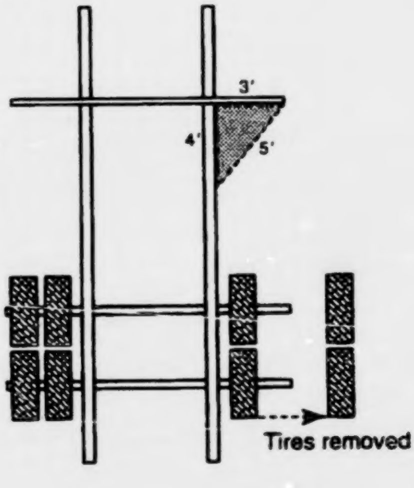


Courtesy of Navistar International Transportation Corporation

☐ c. Mark the frame rail exactly 4 feet back from the bar stock. Then mark the bar stock exactly 3 feet out from the frame rail. If the diagonal measurement (hypotenuse) is exactly 5 feet, then the triangle you made was a right (90°) triangle and the bar is square (or perpendicular) to the frame.

Note: This is a shortcut way of using the Pythagorean theorem without having to do the math if you remember $3^2 + 4^2 = 5^2$. If you use other dimensions, solve using the formula $A^2 + B^2 = C^2$. If the actual diagonal measurement is different from the calculated diagonal measurement, then you know the triangle is not a right triangle and the two sides are not 90° apart (squared up).

Figure 3



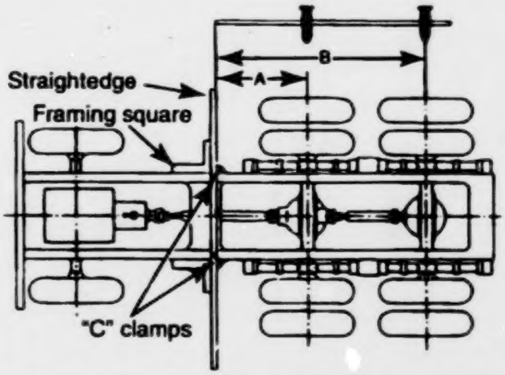
☐ 6. Have your instructor verify that the bar stock is square to frame now.

Bar stock is clamped correctly to frame: _______ (instructor initials)

☐ 7. Suspend the plumb bobs from the bar stock.

☐ 8. Use the trammel bar to measure the distance from the bobs to the rear axles on each side of the vehicle.

Figure 4



Courtesy of Navistar International Transportation Corporation

☐ 9. Record the "A" and "B" dimensions on the job ticket.

Dimension "A" left side _______ right side _______

Dimension "B" left side _______ right side _______

☐ 10. Have your instructor verify these measurements now.

Dimensions "A" and "B" are accurately measured: ______ (Instructor initials)

☐ 11. Go to Step 12 if the difference in dimensions from side to side is more than 1/8". The axle alignment must be adjusted. If dimensions show good alignment, go to Step 15.

☐ 12. Alignment adjustment procedures will vary according to the suspension design. Refer to the vehicle service manual or suspension manufacturer's manual for specific instructions. Three basic methods are described as follows. Remember to chock the front wheels and release the brakes on the rear axles. If the brakes are applied, the axles will be very difficult to adjust.

  ☐ a. Suspensions which use torque leaf springs use eccentric bushings in the torque leaf. Loosen the bushing retaining nut and turn the bolt head slightly. The bushing will turn with the bolt, and since they are eccentric, the torque leaf will be moved forward or aft. Remeasure dimensions "A" and "B" to determine how much to rotate the bushings. Dimensions should be rechecked after the retaining nut is tightened. Record the retaining nut torque on the job ticket.

  ☐ b. Suspensions with rigid torque arms use shims or washers to change the effective length of the torque arm. Adding or removing shims at the torque arm bushing mounting bolts will adjust the axle alignment.

  ☐ c. Suspensions with adjustable torque arms are adjusted by loosening the pinch bolts on the torque arm and turning the center screw.

☐ 13. Roll the vehicle back and forth to "settle" the suspension and recheck dimensions "A" and "B" on left and right sides.

☐ 14. Have your instructor verify your measurements.

Dimensions "A" and "B" are accurately measured: ______ (Instructor initials)

☐ 15. Turn in job ticket when finished.

☐ 16. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ______

Address ______

Phone # ______

Date In ______

Date Out ______

JOB TICKET

Customer Name ______

Customer Address ______

Customer Phone # ______

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ______

Services/repairs made: ______

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

______ Date ______

Technician ______

Supervisor ______

Objective 18

Job Sheet 6—Measure and Adjust Pinion Angle

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Directions are followed	______
• Safety procedures are followed	______
• Slope measurements are accurate	______
• U-joint working angles are correctly computed	______
• Pinion angle is correctly adjusted	______

Basic Skills

Reading Writing Mathematics Critical Thinking Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Technician's common hand tools
- Appropriate service manual
- Job ticket or work order—one is included or use appropriate one provided at your facility
- Floor jack
- Spirit level or inclinometer
- Vehicle needing alignment checked
- Others—as recommended by instructor and equipment service manual

Guidelines

- Pinion angle is determined by the suspension components. If it is incorrectly adjusted, the drive line may cause vibrations.
- If the pinion angle is specified by the vehicle manufacturer, you may skip Steps 6-8. If the specifications are unknown, you must calculate the working angles of each u-joint and adjust the suspension until the working angles at each u-joint are within one degree of each other.

Procedure

☐ 1. Locate and follow the appropriate procedure in the service manual.

☐ 2. Complete the accompanying job ticket with all pertinent information.

☐ 3. Park the vehicle on a level surface.

☐ 4. Drive the vehicle forward and backward slowly, allowing it to stop without making a hard brake application. This "settles" the suspension.

☐ 5. Chock the front wheels and leave the park brakes released. Remove the ignition key.

☐ 6. Use a spirit level or an inclinometer to measure the slope of the engine/transmission. Measure only on a machined surface of the engine block or transmission.

☐ 7. Record the degrees and direction of slope of the engine/transmission in Table 1 or on the job ticket.

☐ 8. Measure the slope of the driveshaft (on a clean surface of the shaft) and record the degrees and direction of slope in Table 1 or on the job ticket.

☐ 9. Measure the slope of the rear axle pinion shaft following these steps:

  ☐ a. Jack up one rear wheel just enough to clear the floor.

  ☐ b. Rotate the driveshaft until the pinion yoke lugs are vertical.

  ☐ c. Remove the top u-joint bearing and place the spirit level crosswise on the machined surface of the yoke.

  ☐ d. Carefully rotate the driveshaft until the pinion yoke lugs are exactly vertical.

  ☐ e. Lower the jack.

  ☐ f. Place the level lengthwise on the machined surface of the yoke.

☐ 10. Record the degrees and direction of slope of the pinion shaft in Table 1 or on the job ticket. If the pinion angle specification is known, skip to step 13.

Table 1

	Degrees of Slope	Direction
Engine/transmission	______	up down
Drive shaft	______	up down
Rear axle pinion	______	up down

☐ 11. Calculate the working angle of the transmission u-joint. Record in Table 2 or on the job ticket.

  ☐ a. If transmission and driveshaft both slope in the same direction, subtract the smaller slope from the larger.

  ☐ b. If the transmission and driveshaft slope in opposite directions, add the slope angles together.

☐ 12. Calculate the working angle of the axle pinion u-joint. Record in Table 2 or on the job ticket.

  ☐ a. If the driveshaft and pinion both slope in the same directions, subtract the smaller slope from the larger.

  ☐ b. If the driveshaft and pinion slope in opposite directions, add the slope angles together.

Table 2

Transmission u-joint working angle _______

Axle pinion u-joint working angle _______

☐ 13. If the working angles are not within one degree of each other, or if the pinion angle is not at the manufacturer's specification, you must adjust the rear suspension. If the working angles are okay, go to Step 16.

☐ 14. If the vehicle has tandem suspension, the pinion angle must be measured and adjusted on both axles.

☐ 15. Refer to vehicle manufacturer's or suspension service manual for specific instructions. Pinion angle adjustment procedures vary slightly depending on suspension design. Basic adjustment methods are:

  ☐ a. If the rear axle has a torque rod mounted lengthwise from a crossmember to the top of the rear axle housing, changing the length of this rod will change the pinion angle. Torque rods may be threaded or may use shims at the torque rod ends.

  ☐ b. If the rear axle has torque rods only at the spring hangers, the pin-on angle is adjusted with tapered shims between the axle seat and the spring or by changing the axle seat to a different angle.

☐ 16. Turn in job ticket when finished.

☐ 17. Clean work area and return tools and materials to proper storage.

Evaluator's Comments: ____________________

____

____

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ________________
Address ________________
Phone # ________________

Date In ________
Date Out ________

JOB TICKET

Customer Name ________________
Customer Address ________________
Customer Phone # ________________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ________________

Services/repairs made: ________________

LABOR	

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

________________ Date ________

Technician ________
Supervisor ________

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